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5 December 1979

USSR Report

RESOURCES

(FOUO 27/79)

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USSR REPORT

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ELECTRIC POWER AND POWER EQUIPMENT

NEWS ITEMS OF CONSTRUCTION AND INSTALLATION

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 9, 1979 pp 43-44

[Text] In almost 100 years there have been devastating floods on the Dniestr River 14 times in the region of the construction of the hydraulic center. This spring the city of Mogilev-Podol'sk was flooded. To regulate the run-off of the water, direct its power to enterprises and its water to the fields of the Ukraine and Moldavia, it was decided to build the Dnestrovskiy hydraulic center with a hydraulic electric power plant with a rated capacity of 702,000 kw and an average annual output of 0.8 billion kw-hours, in the center of the river.

A considerable volume of earth and rock work in the construction has been completed; the Dniestr was spanned, ground removal from the GES foundation pit is being completed and concrete is being poured in the GES building. The Novodnestrovsk Settlement appeared near the future hydraulic center.

In order to be able to put the first units in operation in the GES in 1981, the builders and installers must erect the GES building, build a dam across the river, prepare the water storage area for flood waters and install the power units.

* * *

Preparatory work on building the Dugavpilsskaya GES on the Daugava River in the Latvian SSR has begun. This will be the uppermost GES of the Dugava Cascade (the Plyavin'skaya, Kegunskaya and Rizhskaya GES are already in operation). Construction machinery and trucks have already been delivered to the construction site. Earthwork has begun on one of the first facilities--a settlement for the builders.

* * *

"The technical-economic substantiation of the first stage of transferring part of the run-off waters of northern rivers to the Volga basin," was admitted for review. It was prepared by the collective of the All-Union Scientific Research and Planning-Surveying Institute for Transferring and Distributing Run-Off Waters of Northern and Siberian Rivers imeni Ye. Ye. Alekseyevskiy. Many scientific and planning institutes and organizations of the country participated in the work on this project.

The technical-economic substantiation of transferring run-offs is based on the idea of utilizing existing waterways through a system of lakes and canals which tie in the Baltic Sea with the Volga River and the Caspian Sea. Part of the run-offs from Lakes Onega and Ladoga, as well as from Lakes Lacha, Vozha, Kubenskiy and the Sukhona River can be directed to the south.

The run-off route is selected so that the area of flooded ground will be minimal and, at the same time, revive the dry beds of rivers, in particular, of the Upper Sukhona River. Considerable rebuilding of the existing waterway will be required as well as the creation of more powerful hydraulic centers. The power and the output of the GES on the run-off transfer route will increase. Navigation conditions are improving.

Still another possible run-off direction, the Pechorskoye, was considered. To regulate the water run-off along the canal route, large water reservoirs will be created. The route will come out to the Volga-Kama Cascade of the hydraulic center. Noted scientists and specialists of the most varied specialties were attracted to the consideration of the technical-economic substantiation.

* * *

Over the snowy mountain passes of the Pamir Mountains, Tadzhikistan aviators delivered the first poles of an electric power transmission line to the installers. This line will carry current from the Nurekskaya GES to the kishlaks located in the high mountains of the Komsomolobadskiy Rayon.

* * *

The machine operators have dug the bed of the main line canal, carrying the Amu-Dar'ya water to the Karshinskaya Steppe farther north. The length of the artificial river will be increased by 30 km and provide water to about 170,000 more hectares of dry land. The 132 km Karshinskiy Canal will become a quarter longer and considerably more land will be irrigated than in the first stage of the canal.

* * *

In July 1979, the Priozernyanskaya irrigation system was put in operation in the Kiliyskiy Rayon. It supplied water from the Danube for irrigating over 1000 hectares of fields planted in corn, vegetables, feed crops and vineyards. Now, almost one third of all arable land in the rayon is irrigated. Water lines are laid to the fields of almost all the farms at Kiliyskiye. They are laid basically underground with only hydrants on the surface. Powerful sprinkling machines are connected to the hydrants. Over 150,000 hectares are irrigated in Prichernomor'ye. Before the end of the year, the area of irrigated fields will increase by 6000 hectares in the oblast.

* * *

The last bucket of earth was removed from the route of the third stage of construction of the Bol'shoy Stavropol'skiy Canal. The honor of doing this was given to the excavator crew headed by D. Pyrin. The earthwork on the canal was completed over a year ahead of schedule. The next job is to face the canal with reinforced concrete plates. The new part of the canal will make it possible to irrigate over 15,000 hectares more of dry land.

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ELECTRIC POWER AND POWER EQUIPMENT

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RAISING THE STRUCTURAL EFFICIENCY OF ELECTRIC POWER PLANTS

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 10, 1979 pp 6-10

[Article by L. B. Sheynman, engineer]

[Text] It is planned to develop power in the European part of the USSR primarily by building powerful nuclear electric power plants which operate most efficiently and reliably in a uniform operating mode. They must be supplemented organically by electric power plants designed for carrying maneuvering functions in the power system.

The plotting of the existing and estimated electric load schedules in the largest power associations on the European region predetermines a volume of new maneuvering capacity being put in operation in the order of 15 to 20% of the capacity of the basic electric power sources (AES) which would provide a reliable electric power supply to consumers.

In connection with the high degree of utilization here of efficient hydraulic power resources,pumped storage electric power plants [GAES] are the most suitable and economically justified for use as maneuvering electric power plants. The possibility of building GAES does not require large rivers and they require considerably smaller amounts of dispossessed land than water-powered electric power plants.

Unlike traditional types of electric power plants, GAES are at the same time generating sources and consumers-regulators, i.e., they equalize the night dip in the load schedule. It should be stressed that in many power systems in the European part of the country, the night dip in the schedule already limits the possibility of the wider introduction of a highly efficient but limited maneuverability block plants, as well as AES, and make it necessary to operate 300 and 500 megawatt thermal power units in variable modes. An analysis of foreign data shows that recently the GAES became more important in power systems as highly maneuverable power sources and as fulfilling the functions of a rapidly introduced reserve and maintaining the normal frequency. This is facilitated by the high maneuverability of the GAES equipment (see Table).

Table

Maneuverability characteristics of various power sources

Electric power plants	Regulated range, % of installed turbine power	Time for getting to full load from "cold" state, minutes
Steam turbine	30-85	90-180
Nuclear	70	390-660
Gas turbine	100	15-30
Hydraulic, river	80-100	1-2
Pumped storage	200-220	1-2

Pump storage electric power plants also work well and are used widely in the synchronous compensator mode.

Because for nighttime charging it uses less than 0.3 kg of conditional fuel per kw-hour of power from basic thermal or nuclear electric power plants, a GAES is better for covering schedule overloads than maneuvering gas or steam turbine electric power plants that burn gas, fuel oil or coal in an amount of 0.5-0.4 kg of conventional fuel per kw-hour respectively of electric power. Thus, the GAES save a considerable amount of gas or fuel oil replacing them with nuclear power or solid fuel. The Zagorskaya GAES which is being built now will save about 0.5 million tons of fuel oil per year.

As a result of the above-indicated advantages, the use of GAES in developed power systems with the predominance of powerful low maneuverability thermal and nuclear electric power plants, solves the problems enumerated above, i.e., they raise the reliability and quality of the power supply and provide a considerable economic effect compared to building special TES. In this case, the GAES have a considerably smaller effect on the environment than other power sources. Due to the favorable effect of the GAES on the operating mode of the equipment of condenser electric power plants which enter into the power system with them, operating costs are reduced because of fewer starts-stops of the thermal units, the number of repairs and idle times of the thermal equipment, and the life of the equipment is increased. According to the decree approved by the USSR Minenergo [Ministry of Power and Electrification] in 1978, "Temporary instructions for determining the economic efficiency of capital investments when designing hydraulic power facilities," mode advantages of GAES are evaluated by a reduction in the estimated costs of 6 rubles per kilowatt of their pump power. This is of a rather large value, making up 10 to 20% of the total amount of the reduced estimated unit costs for the GAES.

As a whole, GAES are characterized by favorable natural and construction-economic conditions with the estimated costs not exceeding, as a rule, 75 to 80% of the cost of gas turbine or other special maneuvering thermal electric power plants considered as replaceable versions in projects. Taking into account the urgency of fuller assimilation of the still unused energy potential of the rivers in the European part of the country, and the acceleration of construction of GAES in this region, the Gidroproyekt Institute executed, in 1976-1977, an investigation on locating GES and GAES in the European part of the USSR.

At present, one experimental GAES, the 225 megawatt Kiyevskaya, is operating in the USSR and two large GAES, the Zagorskaya and the Kayshyadorskaya, 1.2 and 1.6 million kw respectively, are being built.

It is extremely important to obtain a maximum yield from capital investments spent on pumped storage electric power plants. This is achieved by selecting the most efficient facilities, establishing optimal operating modes in the power system for them, introducing efficient and easy to manufacture components and designs that would make it possible to use a flow line technology of construction, and reduce auxiliary work.

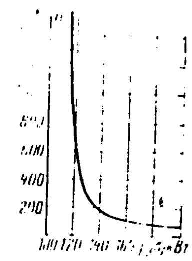
Of the specific natural factors that have a positive effect on the GAES efficiency, the natural drops in the terrain for pumped storage purposes. i.e., the GAES head, should be mentioned first.

As shown by an analysis of a number of our projects, as well as by experience abroad, unit capital investment per kw-hour of installed GAES capacity is reduced hyperbolically as the head increases (Fig. 1). However, drops in the terrain on investigated GAES sites in the center and northwest of the European part of the country where there is the greatest scarcity of maneuvering capacities, do not exceed 80 to 100 meters as a rule.

It is proposed to use high and superjigh heads at the Tereblinskaya and Armyanskaya GAES (about 500 m); at the Stavropol'skaya and, possibly, the Zhigulevskaya GAES (up to 300 m); as well as at the Pana-Yarvinskaya GAES (200 m).

The use of high heads also has certain complications. It is connected, in particular, to the necessity of developing new hydraulic power equipment since, so far, the reversible hydraulic machinery was designed in our country for heads up to 100 m as applied to the Zagorskaya and Kayshyadorskaya GAES.

A standard GAES design is being developed for these conditions at the present time. This design will allow the repeated use of the same water intake structures, water lines, GAES buildings and other structures.



(1)

Fig. 1. Relationship between unit capital investments in GAES with surface reservoirs and heads (for 4.3 hours daily utilization of capacity in the turbine mode).

1. Rubles/kw.

The possibility of full or partial utilization of large natural or artificial bodies of water for storage has a great effect on the economic indicators of the GAES. In the case of building special reservoirs, as is planned in the Zagorskaya and Leningradskaya projects, capital investments for the project as a whole are distributed amoung individual structures and equipment about as follows*, in %, upper reservoirs -- 25; water intakes and water lines -- 20; GAES buildings and substations -- 15; lower reservoirs -- 5; equipment -- 15.

It follows from this that the use of such existing bodies of water as upper reservoirs is especially effective. Regrettably, such possibilities are met with fairly seldom and more often it is necessary to use the existing bodies of water as lower reservoirs. Thus, of the projects planned, only at Pana-Yarvinskaya GAES is it possible to organize the upper reservoirs on the basis of the Iso-Niyeriyays-Yarvi Lake (with an additional backwater), while the lower reservoir will be organized on the basis of the Pana-Yarvi Lake. At the Kayshyadorskaya, Balakovskaya, Zhigulevskaya, Kanevskaya, Dnestrovskaya and Tereblinskaya GAES, previously built water reservoirs of hydroelectric power plants will be utilized as the lower storage reservoirs.

*For using installed turbine capacity 4 to 5 hours daily.

The creation of large enough reservoirs at a relatively low cost (basically by using existing bodies of water) also facilitates raising the efficiency of GAES because of their operation in the"semipeak" mode in accordance with the weekly cycle of storing, i.e., by the partial daily return to the upper water reservoir of the water used during the day and night hours. In this case, the volume of water in the upper reservoir is restored fully during the nonworking days of the week when the system has a surplus capacity.

"Peak" installations are designed to become active in the power system for 3 to 5 hours per day (annual number of hours of utilization of installed turbine capacity in such GAES is equal to 1000-1500), while "semipeak" GAES are designed to span a 10 to 14-hour zone of utilization of the turbine capacity. "Peak" GAES replace GTES [Gas turbine electric power plants] in the balance while "semipeak" type GAES replace more expensive steam turbine maneuvering installations. This, as well as because of the higher system effect, unit capital investments that produce an equal economic efficiency indicator for "semipeak" GAES may exceed the corresponding value for "peak" installations by up to 1.5 times.

It should be stressed that the configuration of existing and estimated electric load schedules in the OES [Consolidated power system] of the European part of the country limits the use of peak GAES, while the introduction of "semipeak" installations will expand the possibility of using pumped storage considerably. Thus, according to the data of the Energoset'proyekt Institute for one of the associations in the power system of the European part of the country, the maximum requirement in peak capacity (1 to 7 hours) will amount to 3300 megawatts in an estimated year, while in a "semipeak" capacity (10 to 17 hours), the requirement will vary from 7200 to 12,700 megawatts depending on the version of electric consumption development.

GAES may be built singly or as part of power (or hydraulic power) complexes. By such a complex we mean a set of two or more electric power plants joined by a common technological utilization of bodies of water, electrical equipment and other installations, as well as joint operation. Joint systematic construction of the individual components of the complex and putting them in operation, stage by stage, is extremely important efficient.

Due to the consolidation of part of the construction and operational managements, transportation facilities and engineering networks, water reservoirs and structures in the complex, a considerable reduction is achieved in the area of assigned land and in capital investments and, as a result, the complex as a whole is more efficient. By combining the functions of the water reservoirs of the power complexes and additional mixing in of the waters when hydraulic storing is done, the cooling in the water supply system of thermal and nuclear electric power plants entering the power complex is improved. In its turn, the run-off of the heated water from TES and AES into storage reservoirs sharply reduces operational difficulties originating in the GAES in connection with ice formation and makes it possible to make the design of the slope reinforcements lighter. Thus, according to the data of the joint work by the Ukraine Department of the Gidroproyekt and the Khar'kov Department of the TEP [All-Union State Institute for the Planning of Electrical Equipment for Heat Engineering Installations], capital investment savings in building the South Ukraine power complex on the Yuzhnyy Bug River, including a 4 million kw AES and a 2.2 million kw GES-GAES, amounted to 8.5% of the total cost with individually constructed facilities. It should be stressed, however, that the indicated paper does not take into account a number of components in determining the saving, namely, the reduction in compensation deductions related to the reduction in the area of dispossessed territory, the reduction in the cost of pits due to the consolidation of pits etc. Thus, the actual saving as a result of creating a large power complex will apparently exceed 10% of the cost o its components. The additional annual saving on the South Ukraine complex is achieved by a reduction of 160 to 170 people in the operating personnel.

Besides the South Ukraine complex, it is also possible to build the Krasnodarsk power complex, including a 1.3 million kw GES-GAES. The use of the reservoirs is planned in both complexes for regulating river run-offs, irrigation and for fishing.

The "power complex" concept also includes a combination of GES and GAES like the Dnestrovskiy complex described below. In the preliminary design of the comprehensive Dnestrovskiy irrigation-power hydraulic center, versions were considered of building a single GES-GAES in line with the supporting structures on the Dniestr River with a maximum head of about 45 m (installed capacity of 850 megawatts, including 250 megawatts of reversible machines) and separate locations for the GES and the GAES. In the latter case, it was planned to install only direct action machines with a total capacity of 600 megawatts at the GES, while the GAES would be located on the headwater side of the hydraulic center, using the basic reservoir as the lower reservoir (the Lomachinskaya site, head about 120 m), or on the tailwater side (Vasil'yevskaya site, head 150 m). In the latter case, the counter regulator-reservoir of the Dniestr GES would serve as the lower reservoir. Both sites were located near the basic hydraulic center which made it possible to utilize fully the construction cadres, the production base and the settlement of the hydraulic center for building the GAES.

The comparison of the plans indicated the undoubted advantages of the version of separate locations of the GAES. Compared to the GES-GAES, this made it possible to increase by 3 to 4 times the pressure in pumped storage, and reduce correspondingly the unit reservoir capacity per kw of stored energy, reduce the unit cost and metal consumption in the reversible machines and, as a result of the indicated circumstances, increase the GAES power.

On the other hand, it was found that locating the GAES on the Vasil'yevskaya site was preferable because the variations in the level of the lower reservoir and its depth in this sub-version is 7 and 11 m respectively compared to 19 and 44 m if the GAES were located on the Lomachinskaya site. This

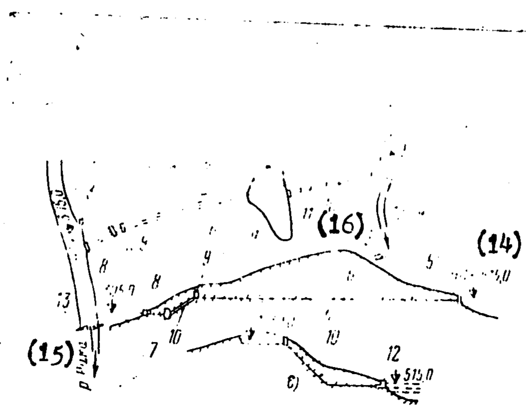


Fig. 2. Tereblya-Rikskaya and Tereblinskaya GAES (planned).
a -- plan; b -- cross section along the pressure route of the Tereblya-Rikskaya GAES; c -- same for the Tereblinskaya GAES.

1. Tereblya-Rikskaya GAES reservoir
2. Diversion tunnel of the GES
3. GES building
4. Dam
5. Tereblya-Rikskaya GAES reservoir
6. Feed low-pressure GAES tunnels
7. Underground machinery hall of GAES
8. Water discharge from GAES
9. Leveling reservoirs of GAES
10. Feed high-pressure tunnels of GAES
11. Upper reservoir of the Tereblinskaya GAES
12. Tereblinskaya GAES building
13. Planned dam and the Berezovskaya GES
14. NPU
15. Tereblya River
16. Rika River

would make it possible to build the Vasil'yevskaya GAES after the basic hydraulic center while in the Lomachinskaya version, it would be advisable to erect the underwater part of the building first (before forming the basic reservoir on the Dniestr River). In connection with the considerably greater depth of the Lomachinskaya GAES building, the volume of concrete is 10% greater and the volume of structural steel 20% greater compared to the Vasil'yevskaya GAES (in comparable versions).

In the final studies it was found advisable to increase the installed capacity of the GES at the Dnestrovskiy center to 700 megawatts and the capacity of the Dnestrovskaya (Vasil'yevskaya) GAES to 2160 megawatts,

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so that the total capacity of the hydraulic power complex would reach 2860 megawatts. The combined utilization of the reservoir-counter regulator, the combining of technological services, the utilization of the construction bases and the settlements of the Dnestrovskiy hydraulic center for building the GAES would result in a saving of 56 million rubles which is 15% of the capital investments in the GAES.

At present, other versions are also being considered for the Dnestrovskiy power complex.

Regarding efficient arrangement solutions, other than the above-mentioned examples of utilizing existing reservoirs for pumped storage, it is necessary to dwell on the arrangement of the Tereblinskaya GAES, building the upper reservoir on the watershed between the Tereblya and the Rika Rivers. At first, it was planned to build the Tereblya-Rikskaya GAES with a capacity of about 1500 megawatts, repeating the arrangement of the existing GES of the same name which uses a drop of 212 m between a reservoir on the Tereblya River and the water level in the Rika River. In this case, it would have been necessary to create a new reservoir on the Rika River in an inhabited region, to form the lower GAES reservoir. It would be necessary to build three feed tunnels 8 m in diameter and 3.5 km long each (Fig. 2) parallel to the existing diversion tunnel.

In the recommended TEO [Technical-economic substantiation] version, it is proposed to build in the first stage a Tereblinskaya GAES with a capacity of 1350 megawatts, using a head of over 500 m. The site occupied by the watershed reservoir has no economic value. The existing reservoir will be used as a lower reservoir.

Because the head increases by 2.5 times, the amplitude of the daily level variations in the reservoir decreases which is of especially great positive importance due to the geological structure of the rivers flowing through unstable rocks of Carpathian flysch.

It is planned to erect the GAES building in the tailwater area of the existing concrete gravity dam (Fig. 3). This will make it possible to place the high pressure reversible hydraulic machines 45 m below the level of the tailwater without building an expensive underground machinery hall and will have considerable economic effect.

At present, the design of the Zagorskaya and Kayshyadorskaya GAES with about a 100 m head acquires special importance. They must become prototypes of a large series of similar electric power plants (Leningradskaya, Balakovskaya, Tsentral'naya, Kanevskaya etc.).

These designs will provide for standardizing the concrete structures -- water feed lines, water lines, GAES buildings, supporting walls, as well as the designs of the embankments of the reservoirs, and will provide for the possibility of industrializing construction.

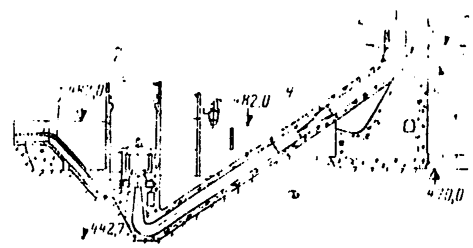

Fig. 3. Tereblinskaya GAES (planned).

1. Existing dam
2. GAES building
3. Steel reinforced concrete feed water line
4. Reinforced concrete diverting water line
5. Water discharge

The greatest engineering complexities come with the manufacture of large diameter (7.5 m) water pipelines to withstand dynamic pressures of up to 160 m and whose total length for each GAES will reach 4 to 5 km. It is planned to make these water pipelines out of steel-reinforced concrete which will save 20% of the metal compared to steel construction. The consumption of very scarce steel sheets will be reduced by about 10,000 tons for each facility.

If the proposed project is adopted, a version of a prefabricated design of the water pipelines made of elements 4.4 m , with 40 cm thick walls and lined with 10 mm thick steel facing, will be used. Individual components of the pipeline are paired and then joined in place into 40 m sections, butt-jointed through compensators. Each water pipeline rests on two parallel beams, supported by two rows of drill-rammed piles which should eliminate uneven settling.

After debugging, the technology of the manufacture, assembly and casting of the water pipelines will be introduced in other series construction facilities. At the same time, investigations are being made in the area of manufacturing prestressed pipelines made of prefabricated components; this will make it possible to eliminate steel facing altogether which will save 8000 to 10,000 tons of sheet metal in each large GAES in the future.

The experience of planning the first large GAES in central and northwestern regions of the European part of the country uncovered a number of complicating circumstances, namely:

unfavorable geological conditions on most construction sites where even gently sloping sides of river valleys are near the equilibrium limit and need to be strengthened. The construction of deep (up to 40 m) foundation pits for GAES buildings etc. is also complicated;

the low slopes of the sides of the valleys make it necessary to build long water pipelines (thus, for practically the same heads at the Ladington GAES in the United States and the Zagorskaya and Kayshyadorskaya GAES in the USSR, the lengths of the feed water pipelines are 382, 649 and 658 m respectively);

in many cases, the complicated, irregular shape of upper reservoir sites requires the construction of safety dikes 25 to 30 m high and the reservoir configuration becomes stretched out, leading to costlier structures and complications in their operation;

several sites lack sufficiently productive pits nearby for conditioning concrete fillers.

It follows, therefore, that a wide search for optimal sites for GAES construction at the TEO stage should be carried out with a considerable volume of proper investigating substantiation and preplanning work which would make it possible to compare throughly all possible versions and to select the most optimal one. It should be expected, however, that a number of the enumerated complications, characteristic of sites for series GAES with a head near 100 m, apparently cannot be eliminated entirely.

It is also necessary to continue a wide search for sites suitable for locating power complexes whose construction will facilitate a reduction in the cost and an increase in the efficiency of GAES and other electric power plants in the complexes. Along with the enumerated ways to improve the design and construction of GAES, it is necessary to continue the systematic development of solutions for new arrangements for the GAES. Primarily it is necessary to proceed with investigation and design work at the TEO stage on series GAES with underground reservoirs (PB). After approval in 1973 of a schematic design of such a GAES for a 1200 m head, research and design work is being continued. The work already done has confirmed the possibility of building GAES with underground reservoirs in northwestern, southern and central regions of the European part of the country. Studies of hydraulic power equipment design made by the LMZ [Leningrad Metal Plant], using the latest foreign data, showed the possibility of the domestic manufacture of multistage reversible 200 megawatt hydraulic machines for the indicated head instead of the previously specified separate installation of the turbine and the pump. This makes it possible to halve the volume and the construction cost of the underground hall (Fig. 4) compared to the schematic design and to reduce the cost of the basic equipment for the GAES considerably. Studies and investigations made by the "Orgenergostroy" Institute indicated the possibility of building the underground reservoir by a mass cave-in of rocks used widely in

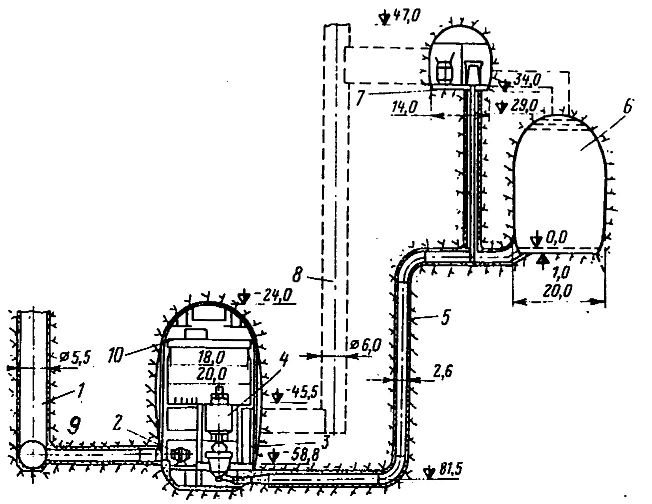

Fig. 4. Machinery hall of a GAES with an underground reservoir (version with a multistage reversible hydraulic machine).

a. cross section
b. plan
1. pressure shaft
2. ball gate
3. reversible hydraulic machine
4. generator drive
5. diverting water pipeline
6. underground reservoir
7. transformer and gate room
8. bus shaft
9. transporting shaft
10. overhead crane

ore mining. This halves the cost of underground quarrying compared to the tunneling as proposed in the plan.

Thus, it is possible to expect a considerable reduction in capital investments for GAES PB estimated at 140 to 150 rubles per kw.

The progress achieved in power machine building makes it possible to expect a further improvement in reversible hydraulic machines for PB of GAES up to the possibility of changing over to 750 and 1500 rpm which would make it possible to simplify the design of hydraulic generators considerably and make them easier to build.

Conclusions. 1. Building GAES in the European part of the USSR is one of the most important problems and is organically tied to the development of power in this region on the basis of preferential construction of high power nuclear electric power plants.

2. Along with "peak" type GAES, it is also advisable to build "semipeak" GAES when favorable natural conditions are present, intended for use 10 to 14 hours per day.

3. Construction of GAES is especially efficient in combination with power complexes, using common water reservoirs. It is necessary to develop a search for sites convenient for creating power complexes and their project design.

4. It is necessary to strive for flow line construction of series GAES with a single type of equipment and standardized structure design. Standardized GAES must be distinguished by technologically efficient designs that will make it possible to maximize industrialized construction.

5. GAES plants with 100 m heads and high pressure GAES with underground reservoirs are recommended for standardization. For the latter it is necessary to develop research and design work at the TEO stage.

6. In connection with complex natural conditions in the majority of GAES sites in the central regions of the European part of the country, it is necessary to carry on the search for optimal sites for GAES construction with higher volumes of research substantiation and preproject analyses that would make it possible to compare the versions considered thoroughly.

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ELECTRIC POWER AND POWER EQUIPMENT

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ECONOMIC EFFICIENCY OF BUILDING PUMPED STORAGE ELECTRIC POWER PLANTS

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 10, 1979 pp 10-13

[Article by B. L. Baburin, candidate of technical sciences]

[Text] The building of pumped storage electric power plants [GAES] is a new and progressive direction in electric power engineering in the USSR. The importance of GAES is determined primarily by the fact that they are a most efficient means of spanning peaks in electric load schedules and taking care of night dips.

The problem of spanning peak loads is due to the increasing disparity between the regulating possibilities of the power equipment and the non-uniform nature of electric load schedules. The aggravation of this problem in parts of the European part of the USSR is due to the change in the fuel-power structure balance occurring at the present time, in particular, the reduction in the share of organic types of fuel in power production, especially gas and fuel oil, and the corresponding increase in the use of nuclear fuel. To provide electric power for the higher rates of growth of the national economy in these areas, it is planned to accelerate the putting in operation of nuclear electric power plants.

The saturation of power systems with nuclear electric power plants not adapted to operating with variable electric loads, will worsen considerably the operating mode of the power equipment of thermal electric power plants if, along with putting AES into operation, no special maneuvering electric power plants are built. Already, at present, with a small ratio of AES in basic power associations of the YeES [Single Power System] of the European part of the USSR, TES power units are used for capacity regulation not only within the limits of their technical minimum load, but in some cases, stopping them during dips in electric load schedules. During 1971-1975, in individual condenser TES, the number of planned stoppages of units per year almost quadrupled. In the OES [Consolidated Power System] of the Center as a whole, the number of stoppages per year per unit increased from 12 to 22; in the OES of the northwest -- from 18 to 34 and the OES of the south -- from 15 to 45.

The operation of thermal power equipment in variable modes leads to greater wear, more frequent malfunctions in the rgulation system, the shut-off fixtures, seals and other equipment units. Each operation in starting and stopping the thermal power unit means additional costs of repairs and changes. Moreover, when a unit is started up there is a certain probability of equipment failure leading to enforced idle time (6 to 8 hours), a repeated start-up and, consequently, to additional expenditures. The effect of the periodical action of temperature stresses on the life of thermal units leading to the accumulation of the so-called small-cycle metal fatigue, is still not clear.

An economic analysis made by the author in the Gidroproyekt on the consequences of using equipment units at TES in variable modes indicated that the total additional expenditures due to equipment wear, its shorter life and greater idle time because of failures and repairs are 3.6 to 4 rubles per kw annually, applicable to power regulation [1]. Therefore, to avoid a considerable increase in expenditures on power systems due to the structure of the increase in power capacities, it is necessary to build special maneuvering electric power plants that will provide normal operating modes of the TES and AES equipment.

The scale of building the necessary maneuvering electric power plants is determined by the degree of nonuniformity in the electric load schedules and the regulating possibilities of the existing and new power equipment. Practice in a number of countries indicates that of the new capacities, 20% and even somewhat more, should be maneuvering electric power plants.

Among all types of maneuvering electric power plants, GAES have a number of advantages which makes it possible to consider them, at the modern stage, the most efficient for spanning the nonuniform part of the electric load schedules. This is explained not only by their high maneuvering qualities, but also by the fact that their presence in the power system improves the structure of the fuel-power balance due to a reduction in the consumption of gas and fuel oil, and the creation of favorable operating modes for TES and AES. Even when compared to the usual GES, GAES differ favorably in the independent mode of their utilization from the rate of stream flow in a particular year, greater maneuverability, better effect on TES and AES operating modes and, in a number of cases, greater efficiency, especially in connection with the fact that the most efficient hydraulic power resources in the European part of the USSR have already been utilized.

At present, only the Kiev 225,000 kw GAES is operated in the turbine mode which is less than 0.5% of all hydraulic power capacities. At the start of 1977, in the United States, of the total of hydraulic power capacities of 67.8 million kw, the GAES capacity was 10.2 million kw or 15%; of the total electric power plant capacity in general use in the United States, the GAES share is about 2%.

The insufficient share at the present time of maneuverable capac...es in domestic power systems, their limited inclusion, including GAES, in the power construction plans is due, in our opinion, to the imperfection of the methods and criteria for optimizing the structure of the generating capacities in the present practice of planning power system development. The optimization methods used do not take sufficent account of the reliability and quality of the electric power supply which depends upon the structure of generating capacities and the operating mode of electric power plants. Traditionally, the main indicators in planning the development of power remain the maximum of electric power output and the minimum of capital investments. Under such conditions, with the limitation in capital investments in electric power, the first that are excluded from the plan are peak hydraulic electric power plants that have a small power output and, especially, GAES that require greater capital investments than special gas turbine electric power plants.

As a result of this approach, difficulties in the operation of power equipment not adapted to operation in variable modes are constantly increasing in power systems, costs of repairing the equipment increase, its life is reduced and the lengths of idle time due to failures increase. In the final result, the quality and reliability of the power supply, i.e., the main indicators characterizing the operation, are reduced.

Smaller dependence of GAES parameters on the rate of the annual stream flow compared to the usual GES, greater reliability of the guaranteed peak power yield, the presence of the pumping mode of operation and frequent switching from one mode of operation to another require new design approaches to the economic substantiation of the efficiency of building GAES. This is especially important because until now one sometimes heard an opinion that inasmuch as a GAES does not produce power but consumes it, putting it in operation complicates the fuel-power balance. In this, the following circumstances are not taken into account. First, in spite of the negative balance with respect to power (the peak electric power at the GAES is about 30% lower than the power consumed in the pumping mode), the total consumption of fuel in the power system when the GAES is put in operation is reduced in comparison with putting in operation an alternative gas turbine electric power plant; secondly, putting the GAES in operation noticeably improves the fuel-power balance structure, increasing the consumption of solid or nuclear fuel and saving gas or fuel oil. Thus, the Zagorskaya type of GAES will consume about 450,000 tons of conventional fuel (solid) annually, and at the same time, reduce the power system requirements of gas and fuel oil by about 600,000 tons of conventional fuel.

The above-noted qualitative features of GAES must be reflected in the quantitative evaluation of their economic efficiency.

In the modern practice of economic calculations in power engineering, a widely used method of comparative efficiency makes it possible to find a solution with minimum expenditures of social labor in the national economy.

The use of this method assumes an equal quantitative and qualitative satisfaction of all requirements of the power system in compared versions of its development with and without GAES. This differentiates in principle the method of comparative efficiency from the method of profitability. If, by comparing to the alternative version, the same effect may be provided in the power system for covering load peaks, maneuverability and improving operating modes of TES and AES, then calculating with respect to profitability all special features of using GAES in the power system cannot be taken into account. The rate for electric power which lies at the basis of profitability takes into account only to some degree the capacity and the fullness of the electric power output of the GAES, but it does not take into account in any way the maneuvering qualities, the mode advantages, and the increase in reliability and quality of the electric power supply on the power system scale.

By using the method of comparative efficiency, the advisability of building a GAES is determined by comparing the costs of building and operating the GAES ($З_{\Sigma}^{гаэс}$) to the corresponding costs ($З_{\Sigma}^{гаэс}$) of the alternative version for developing the power system. Peak gas turbine electric power plants (GTE) that are closest in their maneuvering qualities to GAES should be considered as an alternate source of peak power. The experience of operating the first domestic 100 megawatt gas turbine machines indicated the technical feasibility of their use to cover sharp peak loads, regulate capacities and as emergency standbys, [2, 3].

The building of GAES is considered efficient when the following inequality holds true:

$$З_{\Sigma}^{гаэс} \leqslant З_{\Sigma}^{зам}. \tag{1}$$

Total costs ($З_{\Sigma}^{гаэс}$) are determined by sum

$$З_{\Sigma}^{гаэс} = З^{гаэс} + З_{топл}^{гаэс} + З_{сопр}^{гаэс}$$

where $З^{гаэс}$ -- estimated direct costs for the GAES;
$З_{топл}^{гаэс}$ -- same for fuel for charging the GAES;
$З_{сопр}^{гаэс}$ -- same, associated measures

The determination of the components of the sums $З^{гаэс}$ and $З_{топл}^{гаэс}$ is no different methodologically from the determination of similar costs for the usual hydroelectric plant and qualitatively these costs for the GAES per kw of generator capacity, as a rule, are lower than for the GES.

The second component ($З_{топл}^{гаэс}$) is characteristic only for the GAES. The fuel component of GAES costs is determined by the fuel consumption for charging the GAES and the fuel costs for the given power system according to formula

$$З^{\text{гаэс}}_{\text{топл}} = b_{\text{зар}} Э_{\text{зар}} Ц^{\text{гаэс}}_{\text{топл}}, \qquad (3)$$

where $b_{\text{зар}}$ -- unit fuel consumption per kw of electric power consumed for charging the GAES; $Э_{\text{зар}}$ -- annual consumption of electric power for charging the GAES; $Ц^{\text{гаэс}}_{\text{топл}}$ -- estimated cost of a ton of conventional fuel.

The GAES is chargedduring periods of reduced electric consumption in the power system when a part of the thermal electric power plants operates underloaded. An increase in the load of condenser TES during these periods requires essentially lower fuel consumption compared to charging them additionally in the zone of maximum capacity. For example, for a unit with a K-300 turbine, operating at night with a 180 megawatt load, an increase in its load (to feed GAES pumps) requires an additional consumption of only 270-300 grams of conventional fuel for each kw-hour of additional electric power used, while the average unit fuel consumption of this unit when it is used for 5000 to 6000 hours per year is 10 to 20% more and amounts to about 340 grams. Thus, charging the GAES uses comparatively less fuel. GAES charging from TETs and AES is still more economical.

The practice of the method of comparative efficiency, expressed in comparing the GAES costs ($З^{\text{гаэс}}_{\Sigma}$) with costs ($З^{\text{гтэс}}_{\Sigma}$) for a gas turbine electric power plant of a corresponding capacity replacement for the production of peak electric power,does not contradict the theory of optimal planning and system analysis. Numerous calculations using methods for optimizing the structure of generating capacities in power systems indicate that in the final analysis when there is not a GAES, it is necessary to put sharp peak gas turbines or special semipeak thermal electric power plants in operation.

The practical independence of the constant costs (capital investments in construction and constant annual expenses) of these electric power plants from local conditions makes it possible to accept these types of plants as alternatives with sufficient accuracy without additional optimization calculations.

The systematic approach in the pair-by-pair comparison of versions is expressed in taking account of all changes in the power system, the environment and all industry in the national economy affected by building GAES or alternative electric power plants. Practically, this situation is reflected in electric power plant estimates (costs of water reservoirs etc.), in determining the cost of fuel for the power system as a whole, in the associated costs and in costs related to the compensation for these or other advantages of individual types of electric power plants.

Thus, the total cost for the replaced version ($З_{\Sigma}^{зам}$) is determined by the cost of building the replacement capacity ($З^{ГТЭ}$), the fuel base ($З^{ГТЭ}_{топл}$), associated measures for the water supply, irrigation etc. if, in building the GAES, these sectors of the national economy are affected, as well as by costs in the power system related to the compensation for the participation of the GAES in covering the requirements of the power system in a reactive capacity and power ($З_{ск}$) and in improving TES modes ($З_{реж}$), i.e., in the general case, we obtain the following expression:

$$З_{\Sigma}^{зам} = З^{ГТЭ} + З^{ГТЭ}_{топл} + З^{ГТЭ}_{сопр} + З_{ск} + З_{реж}. \qquad (4)$$

The calculation of all cost components for the version being replaced, with the exception of $З_{реж}$, practically does not differ from a similar calculation of an economic substantiation of the usual GES. It should be stressed, however, that in the European part of the USSR, the estimate of gas and fuel oil in determining $З^{ГТЭ}_{топл}$, in accordance with modern concepts, is 1.5 times higher than the cost of solid fuel. Therefore, in spite of the 30% greater power consumption when charging the GAES compared to the power output during peak periods of the electric load, the introduction of a GAES into the power system instead of a GTE leads to a considerable saving from the standpoint of fuel costs.

The latter component in formula((4) reflects the costs of measures that equalize the effect of the GAES on improving the operating modes of the thermal equipment of the power systems in the version being replaced. The quantitative evaluation of these costs must be made by determining the economic effect of changing the generating capacity structure and the fuel consumption related to this change in the power system as a result of increasing the share of highly efficient electric power plants of the basic type, and a corresponding reduction in the share of peak and semipeak electric power plants when raising the minimal electric loads in the GAES version because of the pumping mode. In this case, the reliability and quality of the electric supply should be the same in all versions of the structure.

For a number of reasons, for example, the lack of reliable technical-economic indicators for peak and semipeak electric power plants, the lack of practical criteria for evaluating the reliability and quality of the electric supply etc., it is not always possible to evaluate $З_{реж}$ by the indicated method. Therefore, of interest is an approximate evaluation of $З_{реж}$ in accordance with the reduction in damages in the power systems when introducing the GAES due to the reduction in the repair costs of the thermal power equipment because of its use in variable modes, the reduction in the duration of idle times due to failures and repairs, and the reduction in the wear of the equipment. An analysis of the data, as already mentioned above, provides a generalized estimate of an additional cost of 3.6 to 4 rubles for each kw of the TES capacity used for regulation or about 6 rubles per kw of pumping capacity of the GAES.

By using the above-cited recommendations for calculating the efficiency of the GAES, it is possible to obtain a generalized indicator for the allowed capital investments in building GAES in the European part of the USSR. Such an indicator has a certain interest for judging the efficiency limit of this source of peak capacity, on the promise of this direction of power development and for preliminary evaluation of the efficiency of a concrete GAES. Such evaluations of allowable capital investments were made in domestic and foreign literature. At the end of the sixties, on the basis of data available at that time on the cost of peak gas turbine electric power plants and the cost of fuel, the allowable value of unit capital investments was estimated at 150 to 160 rubles per kw, i.e., about 20% higher than the cost of a basic KES [Condenser Electric Power Plant] [4]. In this case, only the effect of the GAES in participating in the coverage of the peak load was essentially taken into account. Other functions of the GAES (in particular, improving the TES mode of operation) were not evaluated.

An analysis of cost indicators of GAES abroad, cited for the same period, [5] indicated that along with the very "inexpensive" GAES with favorable natural conditions abroad, there were also built more expensive GAES with a cost 1.2 to 1.6 times greater than the cost of the basic KES. Estimates of allowable capital investments cited by foreign authors [6] that were published later, also attest to the permissibility of costs higher than those mentioned in domestic sources.

To evaluate the allowable capital investments in GAES in the central regions of the European part of the USSR according to modern concepts, fuel costs for charging the GAES should be assumed to be 40 to 43 rubles per ton of conventional fuel and not less than 65 rubles per ton of conventional fuel. for a GTE operating on gas and fuel oil. For unit investments in GTE of 90 to 100 rubles per kw, for 1000 hours of use of the installed capacity, the allowable capital investments in building a GAES, taking into account the effect of the improved operating mode of the basic KES, will be 280 to 300 per kw of installed capacity of the GAES. If it is taken into account that unit capital investments in the GAES to be built in these regions (Zagorskaya, Kayshyadorskaya etc.) are estimated at 160 to 180 rubles per kw, their high economic efficiency must be acknowledged as compared to building peak gas turbine electric power plants.

The economic power analysis of conditions for using GAES in power systems of the European part of the USSR makes it possible to outline two main directions in pumped storage -- the creation of sharp peak GAES, whose storage capacity is calculated for using turbines in the 4 to 6 hour zone of the daily schedule of electrical loads,and building semipeak GAES with a turbine capacity rated for use in the 10 to 16 hour zone of the schedule.

For the same installed turbine capacity, semipeak GAES, unlike the sharp peak GAES, require a 2 to 8 times larger capacity of storage reservoirs. The limited duration of the night dip in electrical load schedules (7 to 8 hours) necessitates the installation of additional pumps for filling the

the larger capacity, or to utilize a weekly nonuniformity of load schedules with a corresponding increase in the reservoir capacities. All of this, naturally, increases unit capital investments compared to sharp peak GAES. Therefore, for semipeak GAES it is desirable to have high heads (150 m and greater) and less expensive storage reservoirs.

Alternative semipeak GAES are the special semipeak steam turbine electric power plants. Using these plants, operating on gas and fuel oil, is limited in the long range by fuel-power balance conditions; the creation of equipment adapted to operate on solid fuel, encounters difficulties of a technical and economic nature. This determines the advisability of building semipeak GAES.

The possible directions in technical solution is pumped storage is building GES-GAES and GAES within power complexes. Unlike the usual or "pure" GAES which working totally with circulating water, GES-GAES assumes the presence of a natural inflow to the upper reservoir. The building of a GES-GAES facilitates the best utilization of the run-off and increases the utilization of the hydraulic potential in cases where building the usual GES without adding a GAES would be inefficient. Moreover, when there are completed water-retaining structures, the cost of the storage part is, as a rule, found to be low enough.

The building of a GAES within power complexes along with a TES or AES has essentially no power advantages compared to their separate construction. Some reduction in power losses in charging the GAES, as a rule, is accompanied by greater power losses when producing peak power. At the same time, building these electric power plants directly near each other reduces the area of dispossessed land and saves the costs of creating construction sites, a construction base and pipelines, while the joint utilization of reservoirs creates better conidtions for cooling the industrial waters of the TES and the AES, simplifies the structure of reinforcing GAES reservoirs due to higher water temperatures in winter and has a number of other advantages in operation.

The planned development of GAES construction in the European part of the USSR requires the most serious attention to the search for the most efficient designs in the construction part, and to the creation of efficient power equipment for the GAES which is new in domestic machine building.

Conclusions. 1. Under present conditions of restructuring the fuel-power balance, building GAES is the most efficient means of solving the problem of covering peaks and night dips in electrical load schedules.

2. Special features of utilizing GAES in a power system require GAES design solutions different from the usual ones and methods of economic substantiation of their parameters and efficiency.

3. The economic evaluation of the operating mode advantages of GAES is determined by the economic efficiency produced by the change in the structure

of the generating capacities in the power system by introducing GAES compared to an alternative version, with the same reliability and quality of power supply in both versions.

4. As a first approximation for evaluating the operating mode advantages of a GAES, a value of reduced costs of 6 rubles per kw of pumping capacity of the GAES may be utilized. This figure was obtained as a result of an economic analysis of damages due to the utilization of power equipment of a TES in variable modes.

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ELECTRIC POWER AND POWER EQUIPMENT

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PROGRESSIVE TYPES OF HYDROELECTRIC EQUIPMENT

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[Article by M. F. Krasil'nikov, engineer and L. P. Mikhaylov, candidate of technical sciences: "Progressive Solutions in the Field of Hydraulic Power Equipment for GES and GAES"]

[Text] Hydraulic turbines. An analysis of the development of hydraulic machine building indicates the following basic trends: an increase in the speed of all types of hydraulic turbines and higher heads, making it possible to reduce the size of the unit and increasing the rotation speed; the introduction of new, progressive types of hydraulic machines, including reversible, diagonal and horizontal encapsulated machines; constant improvement in the power and cavitation qualities of the hydraulic machines and their structural design; an increase to the maximum of the unit power of the machines for superpower hydroelectric plants; improvement in the technology of its manufacture and raising the reliability and life of the equipment.

This analysis also made it possible to normalize hydraulic turbines and, on a scientific basis, develop the basic nomenclature of large pressure turbines, "covering" the entire working range of heads and powers [1]. The nomenclature spans vertical hydraulic turbines with 250-1050 cm diameters of working wheels for adjustable blade turbines and 180 to 850 cm for radial-axial turbines. The nomenclature does not only fix the level reached, but also determines the further development of investigations on creating working wheels with higher technical parameters and characteristics.

To each type of hydraulic turbine, there corresponds its area of optimal heads, namely: with heads up to 20 m, radial-axial hydraulic turbines are used (adjustable blade and propeller); from 40 to 150 m -- diagonal turbines (adjustable blade and propeller); from 45 to 600 m -- radial-axial; above 500 m -- Pelton wheel turbines.

Horizontal encapsulated hydraulic turbines are used widely in the USSR. At present, encapsulated 17.5 to 20 megawatt turbines with 5.5 to 6 m diameter working wheels are being used successfully at the Kiyevskaya, Kanevskaya, Cherepovetskaya and Perepadnaya GES. The Saratovskaya GES operates two experimental horizontal encapsulated turbines which are the largest of this type in the world; the diameter of working wheel of the turbine is 7.5 m. With a rated head of 10.6 m, the turbine develops 45 megawatts.

Adjustable blade axial turbines may be used widely on river hydroelectric power plants with heads up to 80 m. Domestic industry has achieved great success in their manufacture. The turbines of the Volga GES imeni V. I. Lenin and imeni 22nd Congress of the CPSU develop 118 megawatts with a head of 19 m and 126 megawatts with a head of 22.5 m. The working wheel diameter is 9.3 m. To improve turbines of this type,the LMZ [Leningrad Metals Plant] supplied to the Dzherdap-Zheleznyye Vorota (Yugoslavia-Romania) 178 megawatt turbines for a 27 m head with a 9.5 diameter of the working wheel. This is the most powerful turbine in the world of the adjustable blade type while the Saratovakaya GES turbine is the largest in size in the world having a 10.3 m diameter of the working wheel.

In recent years, investigations indicated that the use of double regulation turbines with higher heads is possible by using diagonal turbines whose axis of blade rotation is at a sharp angle to the axis of the working wheel rotation. These turbines have the very important property of preserving high efficiency and a stable operating mode at considerable variations of head and power. Such turbines will find application to small machine GES with low starting heads and considerable variations in head and power. In 1976, 220 megawatt diagonal turbines with a rated head of 78.5 m were put in operation at the Zeyskaya GES. The diameter of the working wheel of the turbine is 6 m (Fig. 1). These are the most powerful diagonal hydraulic turbines in the world at the present time. The experience in operating them indicated that they operate reliably on partial loads and low heads (40 to 45 m). Later the Leningrad Metal Plant developed diagonal hydraulic turbines for a GES being built in the north. They are rated for a still greater head (up to 116 m); their starting head is 40 m and at a rated head of 108 m they will develop 185 megawatts. The diameter of the working wheel of the turbine is 4.2 m.

Propeller turbines are seldom used in domestic practice, regrettably, although with a low head GES with a great number of machines and small head variations, operating in a powerful power system such machines may have technical-economic advantages over the adjustable blade turbines. For example, at Dneproges-II, 115 megawatt propeller turbines with a rated head of 34.3 m and a 6.8 m diameter of the working wheel were found to be more efficient than variable blade 107 megawatt turbines. An essential advantage of propeller turbines is that they do not contaminate the water with leaking oil.

Radial-axial hydraulic turbines are used widely at GES and domestic industry achieved great success in their manufacture. The Krasnoyarskaya GES turbine develops 508 megawatts with a rated head of 98 m and it has a 7.5 m diameter of the working wheel. At present, they are one of the most powerful operating turbines in the world (Fig. 2). The accumulated experience in creating and

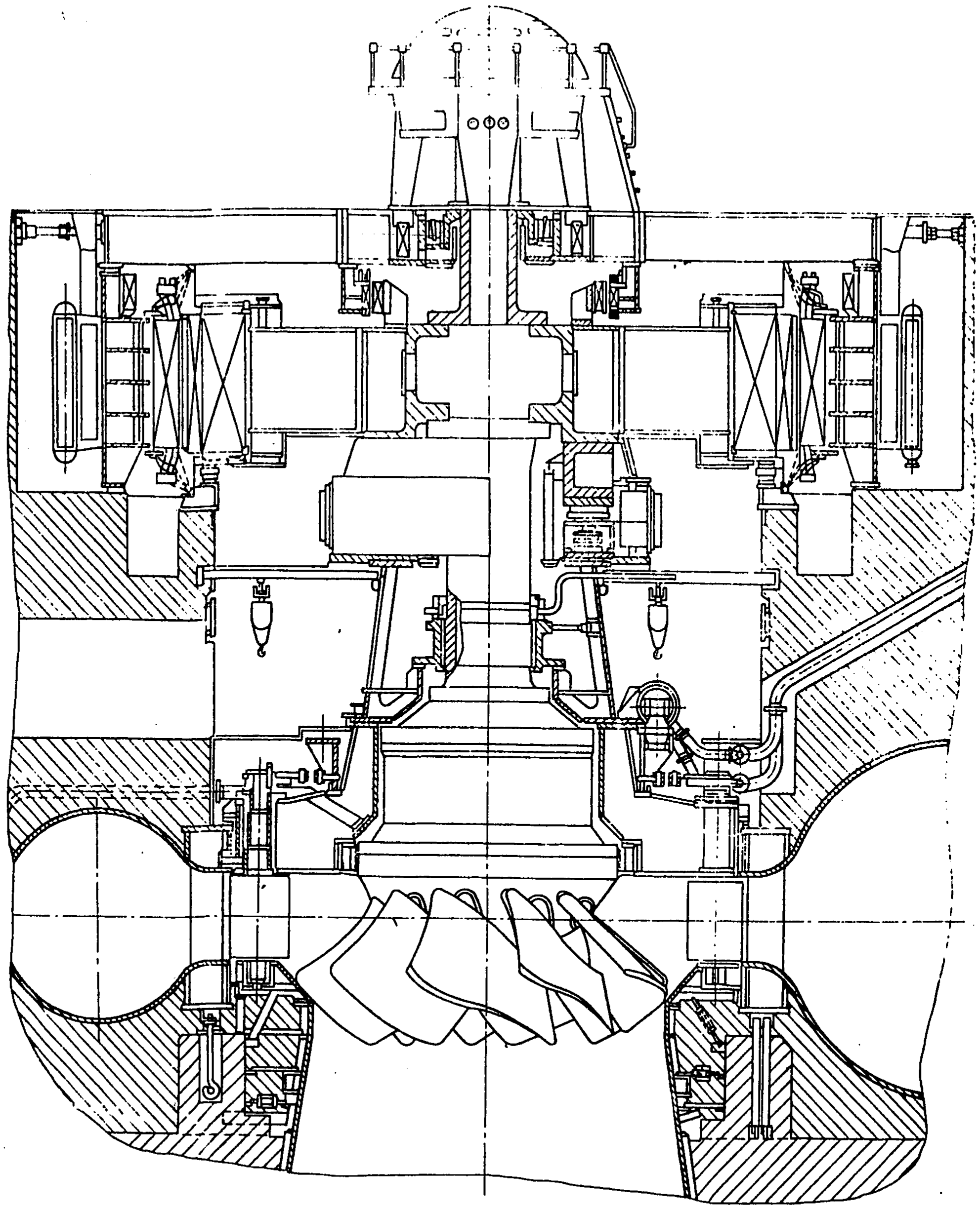

Fig. 1. Cross section of hydraulic turbine at Zeyskaya GES

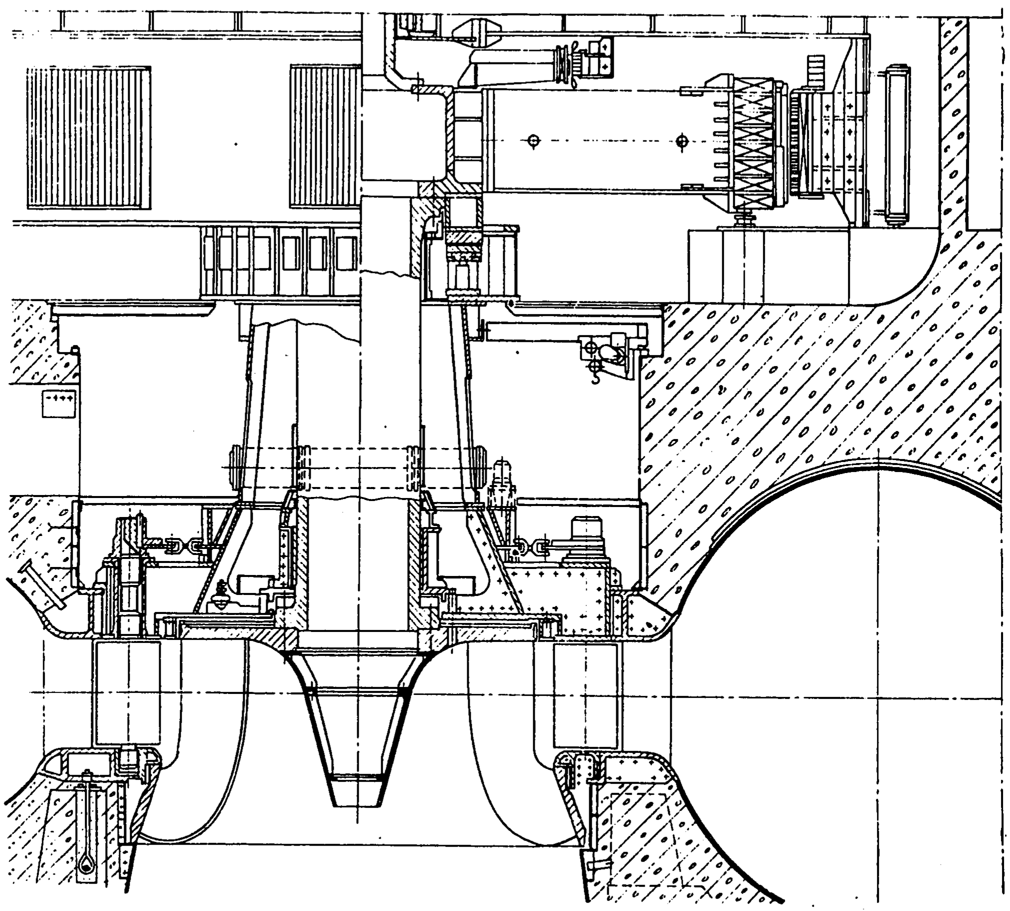

Fig. 2. Cross section of hydraulic turbine at Krasnoyarskaya GES

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successfully operating the Krasnoyarskaya GES turbines made it possible to develop still more powerful turbines for the Sayano-Shushenskaya GES. A high speed radial-axial hydraulic turbine was created with a 6.5 m diameter of the working wheel and a very high efficiency in the optimal zone (95.8%). It develops 650 megawatts with a rated head of 194 m (maximum head, 220 m) and 720 megawatts with a head of 202 m. This turbine with a "regular" working wheel starts operating with a minimum head of 175 m. When operating with a head of 175 m, including at a starting head of 60 m, the first turbines are equipped with temporary working wheels. This idea was implemented for the first time at the Nurekskaya GES and may be (when confirmed by technical-economic efficiency) utilized at other GES with low starting heads.

Serious attention should be given the proposal by the Gidroproyekt and the KhTGZ [Khar'kov Turbogenerator Plant imeni S. M. Kirov] on combining the functions of the hydraulic turbine and the preturbine gate into one machine [2]. It is especially advantageous to introduce this proposal at a powerful high head GES with an underground machinery hall. A cylindrical gate is placed in such a hydraulic turbine between the guiding apparatus and the stator lowered with a closed guiding apparatus and a stopped hydraulic turbine. In this case, seals of the guiding apparatus are not destroyed by the action of the head and there are no cavitation phenomena. The power of the hydraulic unit with a turbine of this type will be 600 megawatts at the Rogunskaya GES with a rated head of 245 m -- maximum 309 m and minimum 220 m (starting head 125 m with the use of replaceable working wheel); the diameter of the working wheel of the turbine is 6.2 m and the diameter of the cylindrical gate is 9.35 m.

To finish off a reliable design, it is proposed to install such a turbine experimentally at the Zelenchukskaya GES (maximum head 241.2 m, rated head 234m, power of unit 80 megawatts, diameter of the working wheel of the turbine 2 m). A similar design is used abroad at the Utard III GES in Canada where four 190 megawatt units were installed for a nominal head of 145 m. The outer diameter of the cylindrical gate is 6.6 m; the drive consists of six screw jacks and oil engines.

Pelton bucket hydraulic turbines are not used widely in the USSR due to the small demand. The most powerful hydraulic turbines of this type were made by the LMZ for the Tatayevskaya GES. These six-jet, 54.6 megawatt vertical turbines operate with a 570 m head. The maximum guaranteed efficiency of the turbine is 91.2%. At present, the LMZ is developing more powerful six-jet bucket turbines for the Zaramagskaya GES. For a rated head of 620 m and a 3.28 m diameter of the working wheel they will develop 178 megawatts at 300 rpm.

Reversible hydraulic machines will be used widely in domestic practice with the expansion of GAES [Pumped storage electric power plants] construction. The use of reversible machines makes it possible to reduce the cost of GAES considerably due to a reduction in the size of the machinery hall and a reduction in basic and auxiliary equipment and the number of feed water lines. At present, single-stage reversible machines are being used successsfully with heads of up to 600 m (for example, in Japan at the Ohira GAES with heads 515 to 548 m) and miltistage machines with heads up to 1000-1100 m are used (for example, in France at the St. Helena GAES with a head of 930 m there are five-stage 88 megawatt reversible hydraulic turbines; in Italy at the Kiotas Piastro GAES with a head of 1070 m -- four-stage reversible 150 megawatt units). Maximum reversible power units in operation at present are the 400 megawatt units at the Raccoon Mountain GAES (United States) with a 316 m head.

Until recently, little attention was paid to GAES construction in the USSR, therefore, their basic power equipment was practically not developed. At present, there are being created dual machine, 200 megawatt reversible units with 200 rpm radial-axial type turbines and single-speed motor-generators for the Zagorskaya GAES. The power of the hydraulic machine at a rated head of 100 m in the turbine mode is 205 megawatts; the maximum power consumed in the pumping mode is 217 megawatts; the diameter of working wheel is 6.3 m and the nominal rotation frequency is 150 rpm. The maximum efficiency of the hydraulic machines in the turbine mode is 92.5% and in the pumping mode -- 90.4%. The installation of similar reversible units at the 1600 megawatt Kayshyadorskaya GAES are planned also.

According to the long-range plan for developing hydraulic power in the USSR, and taking into account the necessary time for developing and assimilating new machines, work has begun on the scientific technical information to be used in designing new, efficient equipment. In particular, the KhTGZ imeni S. M. Kirov developed specification proposals for the Dnestrovskaya, Tereblinskaya and the Tereblya-Rikskaya GAES based on the estimated data. Designs in the form of rough drawings have been completed and the technical possibility has been proven of creating efficient equipment, and estimates of machine characteristics, sizes and weights were made.

A great amount of experience in the design and operation of the technological part of hydroelectric plants made it possible for the Gidroproyekt to develop norms for technological planning of GES which are compulsory for designing GES with capacities of 10 megawatts and greater [3].

The norms specify that the power of the hydraulic unit is selected by a technical-economic comparison of various versions with a varied number of units and, for all technical-economic indicators being equal, the highest technically possible power unit should be selected. The norms defined the basic principles for selecting the turbine parameters (diameter, rotation speed and the suction pressure). Load and head limits were established for which the manufacturing plant guarantees the efficiency, power and suction pressures.

It is permissible to reduce the starting head for axial and diagonal variable blade hydraulic turbines, starting with 40% of the average weighted head (which corresponds to the optimum of the universal characteristic), while for radial-axial turbines -- starting with 50% of the average weighted head. The values of minimal heads and starting with reduced ones are coordinated with the manufacturing plant. If it is necessary to start-up a part of the units at lower heads, it is recommended that versions with replaceable (temporary) radial-axial working wheels or with replaceable hydraulic generators be considered.

Norms were also recommended for the principles of selecting the arrangement of vertical hydraulic units.

Hydraulic generators. As in hydraulic machine building, domestic hydraulic generator building is developing along certain directions, the main ones of which are: the use of hydraulic generators of large unit capacity with water cooling systems for the stator winding; improved designs and arrangements of hydraulic generators; the creation of reliably operating and heavily loaded thrust bearings; the development and creation of powerful generators-motors for the GAES.

In 1967, the "Elektrosila" Plant manufactured the first special design 500 megawatt 93.8 rpm hydraulic generators for the Krasnoyarskaya GES. An achievement of greater power (power per pole is 7.82 megawatts) was found to be possible by using direct water cooling of stator winding conductors and forced air cooling of the excitation winding. In 1977, the same plant manufactured a more powerful hydraulic generator for the Sayano-Shushenskaya GES (640 megawatt generator at 136.4 rpm). At present, the most powerful hydraulic generator is at the Grand Coulee III GES where there are three 615 megava generators with air cooling,and three 815 megava generators with water cooled stator windings are being installed. In the USSR, such a cooling system is used (besides the Krasnoyarskaya GES) for generators of the Sayano-Shushenskaya, Nurekskaya and Ingurskaya GES, and 66 megava at 66.7 rpm are being designed for the Rogunskaya GES. At the Nurekskaya GES, it is planned to install an experimental generator using water cooling of the stator and rotor windings.

Generator design is being improved. To make the generators at the Sayano-Shushenskaya GES more reliable, it was decided to assemble the stator core without joints which required the assembly of the active steel in the stator and the laying of the entire stator winding during installation. A similar stator assembly was used in installing the generators in the Grand Coulee III GES.

To reduce crane equipment at GES buildings of small hydroelectric plants, it is planned to use generators with detachable rotors without rims and poles. The assembly of the rim and the rotor for such generators is done in the unit chamber.

One of the most responsible components of a hydraulic generator is the thrust bearing. At present, basically two types of thrust bearing are being used in the USSR for large generators -- with self-adjusting segments on screw regulated supports and with self-equalizing of the load on hydraulic supports. Depending upon the load, the thrust bearings of the first type are made with one-row or two-row arrangements of the segments. One promising direction in creating reliable heavily loaded thrust bearings is the use of new antifriction materials. Experimental thrust bearing were developed and are working successfully with high unit loads (up 9 megaPa) with the segments being faced with new antifriction materials at the Verkhnesvirskaya GES, the Volga GES imeni 22nd CPSU congress and the Volga GES imeni V. I. Lenin.

In connection with the planned increase in GAES construction, there was the problem of building motor-generators for them. The special features of the reversible machine design are due to the specific nature of its operation in the generator, motor and SK [expansion inknown] modes, with frequent starts and stops, rapid increases and decreases in the loads, multiple switchings etc. In reversible electric machines, reverse rotation is normal when operating in the motor mode, therefore, the thrust bearing and guide bearings must work successfully for both directions of rotation.

For reversible double-machine units, one complex and important problem that affects the design of the units, the reliability and their speed of operation, the arrangement of the GAES and its economic indicators as a whole, is the choice of the starting method in the pumping mode. In the reversible hydraulic units made abroad various starting methods are used -- asynchronous, by means of a special booster motor or starting turbine. In selecting the starting method in the pumping mode, it is necessary to consider the characteristics of the machine, the electric network, and the economic indicators for reliability and fast response.

A direct asynchronous start at full network voltage is the simplest, most economical and fastest method of starting. It does not require additional equipment but produces a large (3 to 5%) voltage drop in the network and higher starting currents. Moreover, direct asynchronous starts present higher requirements to reliable operation of the generator motor and transformer and, therefore, to their design. The securing of the stator windings must be designed for maximal dynamic forces obtained at short circuits at generator terminals. To reduce current surges in the system, asynchronous starting at reduced voltage is used (by a reactor or autotransformer) which, however, requires the installation of additional equipment.

A start by an auxiliary motor or starting turbine reduces surges in the system to a minimum but complicates and makes more expensive the design of the hydraulic unit and the structural part of the GAES.

The advantage of the frequency method (by means of thyristor frequency converters or from another GAES unit, operating in the turbine mode) is a high starting electromagnetic torque transferred to the motor by the system or generator. However, this requires an additional independent DC source for excitation and complicates the starting circuit and increases its time somewhat. One of the most promising (more and more widely used abroad) starting methods is frequency starting by means of a static frequency converter. This method is reliable and may be used for units of any capacity; the converter may be used also for electric braking. The power of the installation is about 8 to 12% of the power of the basic unit and the starting time is 5 minutes or more. At present, static frequency converters are still comparatively expensive, therefore, their use is advisable at multiunit GAES for sequential starting of units (or for starting the first unit with frequency starting of the remaining units from an adjacent machine).

The USSR began making powerful motor-generators only recently. Now the "Uralelektrotyazhmash" Plant developed a 200 megawatt, 150 rpm motor-generator for the first powerful domestic GAES -- the Zagorskaya and the Kayshyadorskaya.

The motor-generator is equipped with a fast-acting self-excitation thyristor system and is designed for direct asynchronous starting in the motor mode with full voltage in the network. The stator windings are secured more strongly and the core of the rotor pole is made heavier. Moreover, a frequency starting from an installation with thyristor frequency converters will be used at the GES. Rough plans of motor generators are being developed for the Dnestrovskaya, Tereblinskaya,Tereblya-Rikskaya and other GAES.

GES automation. Modern hydroelectric plants are equipped with electrohydraulic regulators of rotation frequency of the hydraulic turbines that make it possible to maintain automatically a given bus frequency, and implement group control of the active power of the hydraulic units, introduce additional regulation parameters etc. The pulsing and summing devices in these regulators are electric. On the one hand, this satisfies the best requirements demanded of regulation at multiunit GES and, on the other hand, makes it possible to increase the reliability, life and quality of regulation.

The reliable and efficient operation of powerful power system associations with large electric power plants and long, high voltage electric power transmission lines is possible only when all power system components are equipped with the most modern facilities of comprehensive automation. The complex automation of technological processes is implements especially widely at GES. Telemechanics facilities are used at GES for dispatcher control for transmitting the necessary volume of data on the condition of the basic equipment. The dispatcher center transmits instructions on changing the GES operating mode. The use of intraplant telemechanics using short-range devices makes it possible to reduce capital investment considerably and improve operation. At present, semiconductor devices are being introduced which open up great possibilities for improving circuits and telemechanical devices and raising their operational indicators. GES operation is automated to such a degree that no personnel is necessary for most facilites and there are people only at central control panels. One or two attendants are kept on duty only at some facilities where a great amount of equipment is concentrated (for example, in the machinery hall). The attendants on duty have the task of the general observation of the operating mode of the GES and the equipment, and of taking the necessary measures when there are deviations from given modes, and monitoring the operation of the devices of the general plant and the system.

An automated control system of the technological processes of electric power production (ASU TP GES) is being developed and introduced for GAES and large multiunit GES. The following problems are to be solved by the ASU TP: collecting and processing data; selecting the optimal number and composition of the operating equipment (automatic operator, optimization sybsystem); regulating active power (GRAM); regulating voltage and reactive power (RNRM); emergency control; monitoring the GES mode; recording and depicting data; gathering and analyzing technical-economic indicators.

ASU TP GES is based on a computer control complex (UVK) as a general plant system, controlling the technological process of the entire GES. The economic production problems are solved on the level of power administrations for which purpose there is only a supporting post at the GES for transmitting data to a higher level.

Domestically manufactured standard control machines are used, as a rule, for the UVK. For example, it is planned for the Zagorskaya and the Kayshyadorskaya GAES to use small computer systems with a two-processor SM-2 version.

High pressure emergency-repair and regulating gates. The problem of making high pressure gates became most acute in connection with a combination of high pressure heads at new large GES with high run-offs which made greater demands on the gates, their design, protection against cavitation forces, vibration stability of the gates and their mechanisms, and the reliability of their seals. Making high pressure head gates demands a high standard of production, great precision in their manufacture and, moreover, the use of new high-strength materials for building experimental running and sealing equipment, new types of polyethylene seals with hydraulic clamping at all stages of gate opening, materials with low friction coefficients that are very strong and wear resistant etc.

The Gidroproyekt posed the problem previously of investigating and developing designs of regulating gates for a 200 m head for run-offs of up to 1000 m^3/sec and emergency-repair gates for loads up to 12,000 ton-force at the same 200 m head. There are no gates with such parameters abroad. Because of the lack of technical solutions and critical scientific analyses, it was previously necessary to utilize, in project plans of domestic GES, multistage arrangements of run-off structures, located at a height usually not more than 100 to 200 m intervals (for example, the Nurekskaya GES).

As a result of a great amount of calculations design and experimental work including those on new types of seals and supporting-running parts, participated in by the Gidroproyekt, the "Mosgidrostal'" Special Design Bureau, the "Lengidrostal'" and the VNIIG [The All-Union Scientific Research Institute of Hydraulic Equipment imeni B. Ye. Vedeneyev], technical designs of several new types of gates were developed and substantiated by proper investigations.

Of emergency-repair gates for 200 m heads with an area of up to 60 m^2 of the opening to be covered (flat sliding, flat wheel, flat caterpillar roller) the introduction of the flat sliding gate was recommended for introduction. It is possible to manufacture 1800 ton-force hydraulic hoists for it. A flat sliding gate with the associated ring for a 180 m head and a 5 m diameter of the opening was recently manufactured and installed at the water run-offs of the Ingurskaya GES arch dam. The caterpillar gate is more complicated to make and operate, while the shortcoming of the wheel gate is the transmission of high concentrated loads to parts. Work has also been done on design studies of several other emergency-repair gates -- walking, tubular and arch with hydrostatic unloading.

Of the basic regulating gates for 200 m heads and up to 1000 m^3/sec run-offs (segmental cylindrical, segmental with spherical pressure surface [5] acicular cone-jet, inverse segmental) the gate recommended for introduction in the first stage was the segmental gate with a spherical pressure surface which may be installed in the middle of the water line, as well as at the end, at the outlet. The acicular cone-jet gate can be installed only at the end of the water line, it has a worse weight characteristic compared to the segmental one, it is more complicated to manufacture and less convenient to operate. The positive quality of the inverse segmental gate is that its feet operate in tension, its supporting joints are outside the flow zone and are located on the lead-in connecting pipe; in hydraulic respects, it is inferior to other segmental gates.

Design studies were also made on other new types of regulating gates using hydrostatic unloading: a flat balanced gate with deep slots; a single- and double-segment gate; a flat gate with a reverse pressure chamber above the gate; a flat diaphragm gate, etc. The shortcoming of all gates with hydrostatic unloading is the use of a double sealing contour subjected to high pressures.

Another problem related to building high pressure head hydraulic centers is the attenuation beyond the basic regulating gate of the surplus kinetic energy of the high speed flow. New arrangement solutions for high pressure head run-off structures must provide for the attenuation of a part of the surplus kinetic energy of the flow directly beyond the gate chambers within the tunnel and must utilize efficient means to fight the destruction of the run-off channel components by cavitation. A search for such solutions as applied to (initially) the run-off structures of the Rogunskiy hydraulic center is being made by the Gidroproyekt, the Special Design Bureau of the "Gidromontazh" Trust, the MISI [Moscow Order of Labor Red Banner Engineering Construction Institute imeni V. V. Kuybyshev] and the VNIIG.

One solution that makes it possible to improve considerably the operating conditions of high pressure head run-offs is the use of a twisted flow. In this case, the working surfaces of the turbulent run-offs are under more favorable cavitation conditions than in ordinary tunnel run-offs which is due to the excess pressure caused by centrifugal forces, originating when the flow is twisted. The most efficient attenuation of the high speed flow is provided by a junction of two and more streams twisted into one or in opposite directions. Arrangements are also being investigated about the collision of opposite flows, with an attenuation chamber etc.

Conclusions. The solution of the following basic problems is required for further introduction of progressive technical solutions in the field of hydraulic power equipment:

1. Develp and make efficient reversible hydraulic units, devices for starting them in the pumping mode, apparatus and systems for automatic control and regulation; expand research on finishing off the elements of the flow-through channel and the unit as a whole, thorough study of all stationary and transient modes, processes of starting the unit in the pumping mode and in reverse, operation of the reversible hydraulic machine in the synchronous compensator mode; thorough study of electric equipment operation (switches, transformers, disconnects etc.) under conditions of frequent starts and stops of units, make long-range studies on basic GAES equipment, including high pressure head GAES of the shaft type.

2. Assimilate special design 640 megawatt hydraulic units of the Shushenskaya GES making the necessary tests under natural conditions; develop for the Rogunskaya GES (H=318 m, N=3600 megawatts) radial-axial hydraulic turbines of new design combining the functions of a turbine and a gate.

3. Develop and introduce further a hydraulic turbine of the diagonal type: assimilate the DPL-turbines at the Zeyskaya GES making tests under natural conditions, make turbines for the Kolymskaya GES which is being built, analyze the possibility of using turbines of this type at the planned Mokskaya (head up to 140 m, power of unit 260 megawatts), Sredne-Yeniseyskaya and Osinovskaya (head 55 m, power of unit 500 megawatts) and other GES.

4. Investigate and develop powerful hydraulic units with turbines of the Pelton bucket type for the planned Zaramagskaya and Dar'yal'skaya GES (head 630 m, power of unit 180 megawatts).

5. Study further methods for attenuating flow energies, develop and introduce optimal arrangements for mechanical equipment fo 200 m heads and 1000 m^3/sec. run-offs, making recommendations for designing concrete GES.

6. Expand the search for progressive efficient solutions for designs and outlines of turbine units; continue the study of the hydraulic turbine units, including transient and unstabilized processes, pressure pulsations in the flow-through channel and cavitation phenomena in order to raise the operating reliability.

7. Develop and introduce ASU TP for GES and GAES, including the development of the necessary sensors.

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ELECTRIC POWER AND POWER EQUIPMENT

NEWS ITEMS OF CONSTRUCTION AND OPERATION

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 10, 1979 p 42

[Text] At the start of August 1979, ship locks of the Nizhnekamskiy hydraulic center were put into full operation. Lock controls are centralized and provide full safety and reliability of movement even at the highest water pressures. The locks can also operate automatically. Some 160 ships and about 10 rafts pass through the locks daily.

Some 475,000 m^3 of concrete and reinforced concrete were poured into the locks. The best collectives of builders and installers, using the progressive method of combined work, tested at construction sites of the Kama Motor Vehicle Plant, released the facilities to the operation people on a tight schedule.

Concrete pouring began on the helical chamber of hydraulic unit No 2. The turbine is being manufactured at the Leningrad Metal Plant.

Work is developing on installing the turbine stator in the crater of the No 3 hydraulic unit. It is planned to start pouring concrete for the cover of the helical chamber at the beginning of August.

The working wheel for the third hydraulic unit was delivered to the construction site of the Kegunskaya GES on the Daugava River. In August the crane will be moved to the axis of the hydraulic unit and the working wheel will be lowered into the crater of the unit.

The analysis of the government expert of the technical design of the Boguchanskaya GES on the Angara River was completed. The solutions adopted in the technical design are basically expedient and are sufficiently substantiated by engineering and scientific research data. Therefore, the design was acknowledged to be according to modern technical standards of hydraulic power construction and was recommended for approval.

Technical-economic substantiation is being completed for protection against the flooding of Brest and the land between the Zapadnyy Bug and Mukhovets Rivers.

During the flood period, the Zapadnyy Bug floods about 20,000 hectares of Soviet territory and 22,000 hectares of Polish territory. Some 13,500 hectares of our arable land the 16,500 hectares of Polish land will be protected. It is planned to erect 146 km of dikes on Soviet territory and 110 km of dikes and 13 banking complexes on Polish territory. We will reclaim over 8000 hectares of our protected land.

Brest was given special consideration in the technical-economic substantiation. Four versions of protecting the city from floods were considered and thoroughly analyzed. The most efficient version was selected -- with land fills in the area of new inhabited districts to above flood level. Dikes will be built on the Bug River side.

At the Kislogubskaya Tidal Electric Power Plant, tests were started on introducing new experimental units with variable rpm generators into industrial operation. The idea of such a machine belongs to doctor of technical sciences, former world chess champion, M. Botvinnik. The tests will check on how motor generators with variable rpm acquit themselves in practice.

In June 1979, the dam of the Tuyamuyunskiy hydraulic center being built on the Amudar'ya River in the Uzbek SSR reached the rated height of 40 m. An intensive prestarting time began for the construction of this important hydraulic structure for Central Asia -- the collective of the "Tyamuyungidrostroy" began preparation for damming the river.

The shipping of freight for the national economy increased eight times (from 5 million tons to 40 million tons per year) on the Volga-Baltic waterway imeni V. I. Lenin in the 15 years of its existence. The route of this waterway stretches for 1000 km from the Gulf of Finland to the Rybinskiy Reservoir. Tens of thousands of vessels sail this route annually. A great amount of work was done on the Ivanovskiye rapids, the most difficult rapids for the river people. At present, two-way traffic is open over the entire Neva River.

Some 39 old locks were replaced by seven improved structures meeting all modern shipping requirements. Another automatic lock will be built at the Sheksninskiy hydraulic center. The lock will be capable of handling ships of greater tonnage.

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ELECTRIC POWER AND POWER EQUIPMENT

FALALEYEV'S 60TH BIRTHDAY

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 10, 1979 p 44

[Text] This is the 60th birthday of Pavel Petrovich Falaleyev, the first deputy of the USSR Minister of Power and Electrification and honored builder of the Uzbek SSR.

After graduating from the Moscow Power Institute in 1943, Pavel Petrovich worked for over 20 years in the Uzbekgidroenergostroy Trust directly on construction as well as in the trust apparatus, having passed a glorious labor road from foreman to trust manager.

In 1953 he was sent to study in the Power Engineering Academy which he completed successfully in 1955.

In 1957 P. P. Falaleyev was appointed the Minister of the Construction Materials Industry of the Uzbek SSR and in November 1968 -- the first deputy of the USSR Minister of Power and Electrification.

Along with organizing power construction, P. P. Falaleyev participates actively in guiding the construction of such most important national economic facilities as the Volga and Kama Motor Vehicle plants etc. At present, he heads the work on building the Olympiad facilities in Moscow.

For his great service in power construction and the development of power and electrification in the country, P. P. Falaleyev was awarded the Order of Lenin, the Order of the October Revolution, two Orders of the Labor Red Banner, three Orders of the "Honor Emblem," medals, as well as honorable certificates of the Presidium of the Supreme Soviet of the Uzbek, Tadzhik and Turkmen SSR.

P. P. Falaleyev successfully combines his production activity with considerable social activity. He was elected deputy of the Moscow City Soviet of People's Deputies. At present, he is the chief editor of the "Energeticheskoye Stroitel'stvo" handbook.

In congratulating Pavel Petrovich Falaleyev with a glorious jubilee, the editorial board of the GIDROTEKHNICHESKOYE STROITEL'STVO Journal wishes him good health for a great number of years and further creative successes in his fruitful activity for the welfare of our great Motherland.

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FUELS AND RELATED EQUIPMENT

UDC 622.004.18:[339.45:662.6/.7]

IMPORTANCE OF USING FUEL, ENERGY EFFECTIVELY IN UKRAINE DISCUSSED

Kiev UGOL' UKRAINY in Russian No 9, Sep 79 pp 1-4

[Article by candidates of economic sciences V. V. Nezhentsev of ENII of UkSSR Gosplan and M. Ya. Ayzenberg of UkSSR Gosplan: "Problems of Increasing the Utilization Effectiveness of Fuel and Energy Resources in the Ukrainian SSR"]

[Text] In the modern era of the world's economic development, the fuel and power problem is an extraordinarily severe one. The economic growth of any state is impossible without the use of fuel and power resources (TER). In the last 27 years alone (1951-1977) world demand for TER increased from 2.8 to 9.7 billion tons of standard fuel equivalent, or 3.5-fold, while the demand has increased 1.7-fold for coal, 5.9-fold for oil, 7-fold for natural gas, and 2.8-fold for hydroelectric power. The structure of world demand for TER is now as follows: coal 27.7 percent, oil 41.4 percent, gas 20.4 percent, hydroelectric power 5.3 percent, peat 3.6 percent and nuclear energy 2.1 percent.

Among our country's fuel resources, coal has had an important role, during both the creation of the supply and equipment base for socialism and the period of a developed socialist economy. The rapid pace of increase in the recovery of oil and natural gas in our country since the start of the 1960's has not lessened coal's importance in the USSR's fuel and power balance. At the same time, in the capitalist world the sharp drop in oil recovery has been reflected in the developed countries extremely markedly in the coal industry, especially in such large coal-mining countries as Great Britain, the FRG, France and the USA. It is oil (more correctly, the price of oil) that is one of the chief causes for the appearance of the energy crisis. In Tokyo, in June 1979, the leaders of the seven largest capitalist countries were forced to pay the most serious attention to problems of restricting oil imports, increasing investment in national fuel and power industries, saving fuel and power, and reexamining attitudes toward prospects for developing the coal industry.

The Communist Party and the Soviet Government, relying upon Leninst principles for developing the country's fuel base, have, since the first days of the creation of the socialist state, assigned an important role to supporting the growth of coal mining, oil and gas recovery, and the winning of peat. The rapid pace of growth of the USSR's economy has brought about a headlong increase in the demand for TER--from 64.4 million tons of standard fuel equivalent in 1913 to 1,989,300,000 tons in 1977, or 30.9-fold.

Satisfaction of the national economy's TER requirements with complete self-reliance for all types of primary fuel became possible thanks only to intensive development of the country's fuel and power base. The CPSU's strategy in the area of the geological study of our country has enabled enormous reserves of coal, oil, gas, peat and so on to be explored. During 1951-1977 alone, the recovery of all types of fuel in the USSR (computed on the basis of standard fuel equivalents) grew 5.5-fold--2.4-fold in the case of coal, 14.4-fold for oil (including gas condensate) and 56.2-fold for gas.

The rapid pace of development of the USSR's fuel base has made it possible not only to satisfy the national economy's requirements for fuel completely but also to send coking coal and anthracite, crude oil, petroleum product and natural gas to the socialist members of CEMA under the program for socialist integration, as well as to some capitalist and developing countries under bilateral agrements. The value of fuel resources (solid fuel, gas, crude and petroleum product) now being exported is 11.4 billion rubles per year (according to 1977 data). The share of fuel resources (not counting electric power) in total USSR exports is 34.5 percent.

Increase in the scale of our country's industrial and agricultural production, the burgeoning growth of housing and municipal-services activities, and the rising standard of living of the Soviet people require an increase in fuel and power resources. Despite the fact that the production of oil, gas and coal in our country is increasing, we still could not satisfy requirements for fuel and electrical and heat energy fully during, for example, the severe winter of 1978-1979.

Rational and economical use of TER is acquiring great importance at this time. This is emphasized with special force in the CPSU Central Committee and USSR Council of Ministers decree, "Providing the National Economy and the Population with Fuel, Electricity and Heat During the Fall and Winter Period of 1979-1980." It calls the attention of workers of all branches of the economy to the need to intensify the drive to make the most effective and economical use of TER and to save fuel and electrical and heat energy in every possible way.

Among the paramount programs that should be worked out in the near term, the CPSU Central Committee and USSR Council of Ministers decree, "Improving Planning and Intensifying the Effect of the Management Mechanism on Raising Production Effectiveness and Work Quality," specifies the program for saving fuel.

The balanced development of our country's economy depends increasingly upon the state of affairs in the production and utilization effectiveness of TER. Fuel and energy resources are beginning to dictate the pace and scale of development in various areas of industrial and agricultural production and are responsible for successes in solving the social and economic tasks of further raising the material welfare and cultural level of the life of Soviet man.

Unstable operation of various branches of the fuel and power complex, as well as of rail transport, is exercising an extremely painful effect on the supplying of fuel and energy to industrial enterprises, power stations and the people, especially in wintertime. An insufficiency of fuel compels the imposition of certain restrictions on the consumption of gas, mazut, coal, electricity and heat, and this leads to nonregularity in the operation of enterprises and to a reduction in the output of various kinds of products.

The Ukrainian SSR's economy, including branches of the fuel and power complex (TEK), increased its production potential at a rapid pace during the postwar period. During 1950-1978 the production of primary TER in the UkSSR rose 3.7-fold; this not only provided for satisfaction of the rapidly growing demands of the UkSSR's economy for coal, gas and electrical and heat energy but also allowed fuel and energy to be sent to the other fraternal republics and abroad.

During 1960-1977 the structure of the republic's production of primary TER moved in the direction of a gradual reduction in coal mining's share. Thus, while there was an absolute rise in the mining of coal, computed in standard fuel equivalents, from 126 million tons in 1960 to 146.2 million tons in 1977, the share of coal in the republic's total fuel output decreased from 83.4 to 59.6 percent; at the same time, the share of natural gas and oil rose from 13.5 to 38.2 percent. Since the second half of the Tenth Five-Year Plan, the structure of primary TER production in the UkSSR has begun to change, with a rising trend in the share of coal, which will reach 65 percent by the end of 1980, and the share of natural gas and oil has been gradually decreasing.

Fuel consumption in the Ukrainian SSR's economy has been growing intensively: by 18.4 percent during the Eighth Five-Year Plan, 22.5 percent during the Ninth, and about 20 percent (expected in 1980) during the Tenth. The demand for primary fuel resources in the USSR changed direction as follows during the last three five-year plans. In 1965, 32.2 percent of all fuel was consumed to produce electricity and heat, the figure was 35.5 percent in 1970, 39.8 percent in 1975 and it is expected to be 38.6 percent in 1980; correspondingly, 67.8 percent of it was used for industrial production needs in 1965, 64.5 percent in 1970, 60.2 percent in 1975 and the figure is expected to be 61.4 percent in 1980. Consumption of electricity during the Eighth and Ninth five-year plans grew, respectively, by 46.6 and 35.1 percent, and during the Tenth it will increase by 30.1 percent; the consumption of heat energy provided by centralized sources grew by 46.3 and 35.2 percent during the Eighth and Ninth five-year plans, respectively, and it is expected to grow by 27.2 percent during the Tenth.

The most fuel-intensive branch of the UkSSR's economy is industry. It now consumes 84 percent of all boiler and furnace fuel in the republic, and, among the branches of industry, ferrous metallurgy and electric-power engineering are consuming the greatest portion of the fuel; housing and municipal services consume 12 percent, transport 1.4 percent, agriculture 0.6 percent, construction 0.3 percent and other branches 1.7 percent of all boiler and furnace fuel. Industry also is the largest consumer of electricity, and the most electricity-intensive branches are ferrous metallurgy, machinebuilding and the chemical industry. The amount spent on municipal- and domestic-services needs was 10.6 percent, on agriculture 7.7 percent, on transport 5.9 percent, and on construction 1.8 percent.

There has been a trend in the UkSSR in recent years toward a reduction in the pace of growth in the amounts of coal mined and oil and gas recovered that has been especially noticeable since the start of the Tenth Five-Year Plan, because of a worsening of mine-geology conditions for the excavation of coal deposits (especially in the Donbass) and because of depletion and exhaustion of the larger gas deposits. Providing for the effective use of existing resources of coal, oil, gas, electricity and heat and for economy and thriftiness in their use has become one of the most important means for augmenting reserves.

Work has been going on for many years in all branches of our country's economy on behalf of rationalization and savings in the consumption of fuel and energy. Consumption norms are to be reduced by 3-4 percent for boiler and furnace fuel and by 5 percent for electricity and thermal energy during the Tenth Five-Year Plan. In 3 years of the five-year plan the relative requirement for fuel for the country as a whole was reduced by more than 20-25 million tons of standard fuel equivalent (in comparison with the preceding year's norms). The USSR's economy is to save a total of 33 million tons of standard fuel equivalent of TER under the plan for 1979.

There are in our republic, in all branches of the economy, some associations and enterprises that are waging a persistent and purposeful drive for the effective use of TER, a reduction in nonproductive expenditure and losses of fuel, electricity and heat, and constant improvement of the system for setting norms therefor and for accounting for consumption. In the last 3 years of the Tenth Five-Year Plan alone, about 7 million tons of standard fuel equivalent, 6 billion kw-hr of electricity and 20 million kilocalories of heat energy were saved in the republic. Much work is being done in this area at UkSSR Minenergo [Ministry of Power and Electrification] enterprises. Thus, at the Zaporozhskaya and Uglegorskaya GRES's, organizational and technical measures for accelerating the mastery and increasing the operating reliability of power units with individual capacities of 800,000 kw-hr [sic] were accomplished successfully. Preventive maintenance, accident reduction and other measures are being taken at many power stations. In 1978 UkSSR Minenergo enterprises saved almost 190,000 tons of fuel and 484 million kw-hr of electricity.

Almost 2,700 measures to save TER were carried out at the republic's ferrous metallurgy enterprises alone in 1978, as a result of which consumption was reduced by 3 percent for electricity and heat and 1.4 percent for boiler and furnace fuel. The use of secondary energy resources (VER) increased substantially at plants. The share of heat obtained through VER reached 32 percent. Thanks to this, the republic's metallurgy managed to reduce fuel requirements by 2.1 million tons of standard fuel equivalent, or by 9.3 percent.

In the first 6 months of 1979, 260,500 tons of fuel, 10.4 million kw-hr of electricity and 24,230 kilocalories of heat were saved at UkSSR Minmestprom [Ministry of Local Industry] enterprises, organizations and construction sites. The basic tasks for the ministry as a whole to save fuel, electricity and heat, as well as an additional task to save electricity, were carried out.

The Ukrainian SSR is successfully centralizing heat supply in cities and eliminating small, poorly effective boilerhouses. During 1978 alone 130 such boilerhouses were eliminated, 1,200 automatic heat regulators for customers' lead-ins were installed, 36 boilerhouses for heating were placed under centralized control, and so on.

The Ukraine's workers have undertaken commitments to mine 5 million tons of coal and to save 2.6 million tons of standard fuel equivalent, 4.4 billion kw-hr of electricity, 8 million kilocalories of heat energy, 240,000 tons of automotive gasoline, 160,000 tons of diesel fuel and a large amount of crude oil and gas above the plan during the fourth year of the Tenth Five-Year Plan.

Successful fulfillment of these commitments will depend to a great extent upon the work to improve the use of TER and to consume such resources thriftily and economically. Meanwhile, not everywhere is the indicated work being done with the necessary consistency and purposefulness, as a result of which some ministries and agencies did not fulfill the task for saving fuel, electricity and heat in 1978. This refers primarily to such industries as ferrous metallurgy, the coal industry, the building-materials industry and others.

There are still great TER losses at some ferrous metallurgy enterprises because of the nonobservance of optimal technological regimes, the use of obsolete equipment, and incomplete charging of equipment; clearly, not enough work is being done to utilize VER. For UkSSR Minchermet [Ministry of Ferrous Metallurgy] as a whole, the tasks for growth in the volume of use of secondary and incidental heat energy during 1978 were not fulfilled. In particular, a set of measures to reduce losses of secondary fuel gases at the Adveyevka and Yasinovataya byproduct-coke plants and at the Makeyevka Metallurgical Plant was not implemented; additional gas lines for the transmission of coking gases to the TETs of Zhdanov's Azovstal' metallurgical plant were not built by the established deadlines, and installations for evaporative cooling at the Kommunarsk and Donetsk metallurgical plants, as well as waste-heat recovery boilers at some of the industry's other plants, were not introduced. The wide introduction of heat-utilization installations at metallurgical and other production facilities could furnish heating for nearby settlements and municipal- and domestic-services enterprises, thereby saving natural gas or other types of fuel.

Seven rotating kilns that are obsolete are operating within Ukrtsement [Ukrainian Cement Association] of UkSSR Minstroymaterialov [Ministry of Building Materials Industry]. Their specific fuel consumption reaches 326 kg/ton, with an average specific consumption of 226 kg/ton throughout the association for roasting clinker. Such kilns overexpend up to 41,000 tons of standard fuel equivalent yearly. The Kamenets-Podol'sk, Amvrosiyevka and Nikolayev cement plants have not achieved the planned savings of energy resources through improvement of the system for liquefying slurry.

There is a substantial overexpenditure of electricity at UkSSR Minugleprom [Ministry of Coal Industry] underground mines. This relates primarily to Stakhanovugol' [Coal-Mining Association imeni Stakhanov] and Donbassantratsit [Donbass Anthracite-Mining Association] mines, where overexpenditures of electricity were 108.4 and 84.4 million kw-hr, respectively, in 1978. Overconsumption of electricity at the underground mines results from a number of causes, particularly: equipment operates at less than full workload, motors of increased power and a lower level of outfitting for reactive power have been installed at various industrial elements, electricity is expended irrationally in systems for ventilation and water drainage, and so on. The various examples cited do not characterize completely those unused opportunities which the republic's industrial enterprises have at their disposal for saving TER and making use of VER. Work to save TER should be conducted daily at each enterprise, organization and institution. There are many plans for these reserves, which exist both at the enterprises that produce fuel and generate electricity and heat and at enterprises that consume this energy, as well as at organizations that engage in delivering fuel.

One of the important reserves for the effective use of TER is improvement in the setting of norms for the consumption of fuel, electricity and heat. So far, norm-setting is based mainly on statistical reporting data and, therefore, it repeats the deficiencies that are inherent in the existing reporting. Consumption norms for fuel and energy should consider advanced methods of operation and positive results from introducing the achievements of scientific and technical progress. The existing reporting does not reflect completely the picture of TER expenditure within the economy. Scientifically substantiated recommendations for improving the calculation and reporting of specific norms and surpluses and expenditure of TER are extremely necessary.

Every association and every enterprise within the republic has organized a standing commission for saving TER; large-scale surprise inspections and inquiries are called for. At the same time, these are not always conducted actively. The drive for saving TER in every possible way should be conducted constantly. The coal, oil and gas that are produced and the electricity and heat that are generated are the people's property. If fuel and energy are consumed economically, then the requirement for capital investment for branches of the fuel complex is reduced to some extent, and the resources thus freed will be directed toward developing industries that create consumer goods.

As research by ENII of UkSSR Gosplan has indicated, there are at the republic's enterprises substantial reserves for raising the utilization effectiveness of TER and for consuming such resources economically. The most complete use of the various secondary byproducts from the basic production process are an extremely important reserve for augmenting TER. For example, methane that is pumped to the surface during the degasification of coal seams can become a good fuel for boilerhouses. The Donetsk Polytechnic Institute has developed a method for upgrading methane with a small amount of natural gas, which provides for full safety of boilerhouse operation. The boilerhouse of the Mine imeni Gor'kyy of Donetskugol' [Donetsk Coal-Mining Association] is being converted to industrial heating by enriched methane. When coal is hauled by rail, 3-5 million tons are lost (blown off) per year. The miners can sharply cut these losses by compacting the coal effectively in the freight cars, covering the coal with a sprinkled film, and so on.

Examples of the wide involvement of secondary byproducts of basic production for augmenting TER and for the thrifty and economical use thereof can be cited also for ferrous metallurgy, chemicals and other branches of industry. The importance of saving fuel can be judged by the fact that a 1 percent saving of coal in the republic corresponds to 1.7 million tons.

The recycling of domestic trash can become of no small assistance to increasing fuel production. Specific experience has already been gained in some socialist countries (the GDR, Hungary and Czechoslovakia) and capitalist countries. The organization of this production is economically warranted. Computations have established that the UkSSR can produce 2.5 million tons of standard fuel equivalent each year from household trash.

In order to solve tasks for the rational use and saving of TER in the republic, further improvement in accounting for and reporting on the fulfillment of norms and on the volume of consumption of TER, effective monitoring over the expenditure thereof, the introduction of an effective system of economic incentives for a thrifty attitude toward TER, and so on are necessary. In order to improve the soundness, the balancing and the quality and effectiveness of current and long-range plans for developing branches of the Ukrainian SSR's fuel and energy complex, a deep scientific study of such questions as the republic's consolidated fuel and energy balance, the balances for individual types of fuel (coal, oil, gas, electricity and heat), the economical and effective use of TER, wider involvement of secondary fuel and energy resources in the national-economic turnover, and so on are necessary. The time has come when the republic must intensify work to develop production and consumption balances for all types of fuel and energy and to coordinate scientific-research organizations that are occupied with various aspects of this problem. It is necessary to develop integrated, purposeful program for implementing measures that will rationalize the use of and save fuel and energy resources.

The rational and economical use of TER is the most important method of our socialist management, which embraces all branches of the national economy. "Among the major interindustry problems there is none more important than the fuel and energy problem," L. I. Brezhnev emphasized at the December 1977 CPSU Central Committee Plenum. Raising the effectiveness of TER utilization in all spheres of the national economy is a task of nationwide importance.

> The CPSU Central Committee and USSR Council of Ministers decree, "Providing the National Economy and the Population with Fuel, Electricity and Heat During the Fall and Winter Period of 1979-1980," calls for a number of concrete measures for unconditionally fulfilling or overfulfilling tasks for the fourth year of the five-year plan for mining and shipping fuel to customers, creating the necessary reserves thereof at industrial enterprises and electric-power plants, and further increasing the production potential of the coal, oil and gas industries. Special attention was paid to the objective necessity for the economical expenditure of fuel and power resources and the organization of the strictest monitoring over the rational use thereof.
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> In publishing the article, "Problems of Raising the Utilization Effectiveness of Fuel and Energy Resources," the editorial board asks the journal's readers to send contributions, which must show how affairs concerning the use of fuel, electricity and heat are going at specific enterprises, what reserves exist in this field, and what concretely must be done to realize them.

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FUELS AND RELATED EQUIPMENT

UKRAINIAN COAL OUTPUT FOR FIRST HALF OF 1979 SUMMARIZED

Kiev UGOL' UKRAINY in Russian No 9, Sep 79 pp 46-47

[Article: "The UkSSR Coal Industry During the First Half of 1979"]

[Text] During the first half of 1979 the republic's coal-industry workers mined 106.15 million tons of coal, 1.16 million tons of it above the plan. For UkSSR Minugleprom [Ministry of Coal Industry] as a whole, the plan for mining all types of coal was carried out by 101.1 percent (table 1), while the plan for coking coal was met by 102.2 percent.

Having been included in the All-Union socialist competition to fulfill tasks for the fourth year of the Tenth Five-Year Plan ahead of schedule, improved indices were achieved by miners of Donetskugol' [Donets Coal Mining Association], who have 771,000 tons of coal, Torezantratsit [Torez Anthracite-Mining Association] (338,000 tons), Makeyevugol' [Makeyevka Coal-Mining Association] (149,000 tons), Ordzhonikidzeugol' [Ordzhonikidze Coal-Mining Association] (102,000 tons), Donbassantratsit [Donets Coal Basin Anthracite-Mining Association] (413,000 tons), Voroshilovgradugol' [Voroshilovgrad Coal-Mining Association] (206,000 tons) and Krasnodonugol' [Krasnodon Coal-Mining Association] (128,000 tons) to their account above plan. In 1979 UkSSR Minugleprom implemented systematic work to increase the length of existing breakage faces and to raise the level of integrated mechanization and automation of production at the mines.

The number of active breakage faces increased by 130 over the first half of 1978, comprising 1,720 units (table 1). The average working length of breakage faces increased. At the same time, there was an insignificant reduction in their average monthly advance, which was occasioned by deterioriating mining-geology conditions at some longwalls and unsatisfactory use of excavating machinery at various mine faces.

During the first half of the year, new serially produced mining equipment, including mechanized complexes, arrived at the mines. At seams with a dip angle of less than 35 degrees, it was planned to have 499 longwalls with integrated mechanization, to be equipped with cutter-loaders and overhead cutters.

Table 1

Производственные объединения (1)	Добыча угля, тыс. т (2)	Кол-во действующих очистных забоев (3)	Среднедействующая линия очистных забоев, км (4)	Среднемесячное подвигание действующих очистных забоев, м (5)	Суточная нагрузка, т (6): на действующий забой (7)	на шахтуразрез (адм. ед.) (8)
Донецкуголь (9)	11 131	189	33,26	30,3	350	3034
Макеевуголь (10)	7 752	145	22,61	31,0	320	2945
Красноармейскуголь (11)	6 647	82	13,12	42,7	482	3554
Добропольеуголь (12)	5 576	43	7,46	61,8	798	3683
Артемуголь (13)	5 661	231	23,61	29,2	143	2148
Орджоникидзеуголь (14)	3 112	102	10,99	31,3	179	1806
Шахтерскантрацит (15)	6 152	109	18,22	31,5	333	1914
Торезантрацит (16)	5 623	100	15,18	30,3	341	1987
Ворошиловградуголь (17)	5 986	75	12,45	40,5	446	3160
Стахановуголь (18)	4 804	115	19,43	26,3	233	1481
Первомайскуголь (19)	5 075	95	17,00	26,2	332	1905
Краснодонуголь (20)	4 615	53	8,10	46,1	482	2811
Донбассантрацит (21)	11 673	163	27,14	33,4	420	2681
Свердловантрацит (22)	4 817	43	6,70	53,7	683	2241
Павлоградуголь (23)	4 596	57	8,03	57,1	526	3100
Укрзападуголь (24)	7 661	107	12,84	48,0	504	2141
Александрияуголь (25)	5 225	13	1,05	62,0	813	4033
Минуглепром УССР (26)	106 146	1720	257,24	35,1	356	2523

Key:
1. Production associations.
2. Coal mined, thousands of tons.
3. Number of active breakage faces.
4. Average active length of breakage faces, km.
5. Average monthly advance of active breakage faces, meters.
6. Daily workload, tons.
7. Per active breakage face.
8. Per strip mine (administrative unit).
9. Donetsk Coal-Mining Association.
10. Makeyevka Coal-Mining Association.
11. Krashoarmeysk Coal-Mining Association.
12. Dobropol'ye Coal-Mining Association.
13. Artemovsk Coal-Mining Association.
14. Ordzhonikidze Coal-Mining Association.
15. Shakhtersk Anthracite-Mining Association.
16. Torez Anthracite-Mining Association.
17. Voroshilovgrad Coal-Mining Association.
18. Coal-Mining Association imeni A. G. Stakhanov.
19. Pervomaysk Coal-Mining Association.
20. Krasnodon Coal-Mining Association.
21. Donbass Anthracite-Mining Association.
22. Sverdlovsk Anthracite-Mining Association.
23. Pavlograd Coal-Mining Association.
24. Coal-Mining Association of the Western Ukraine.
25. Aleksandriya Coal-Mining Association.
26. UkSSR Ministry of Coal Industry.

Actually, the number of such longwalls was 516, which is 17 units more than called for by the plan. More than 60 percent of all production at seams with dip angle of less than 35 degrees (table 2) is obtained at these mine faces.

The number of longwalls with integrated mechanization at seams with dip angles greater than 35 degrees grew to 57, under a plan for 54, through the introduction of breakage faces with AShch mine supports; and 1.5 million tons of coal were mined, for an average daily mine-face workload of 188 tons.

Sixty-nine longwalls were equipped with overhead cutter installations at gently sloping seams, and 3.24 million tons of coal were mined from these, for an average daily workload of 292 tons per breakage face.

Drifting brigades worked successfully during the first half of the year. The plan for the conduct of all developmental drifting was met by 102.9 percent, including stripping and developmental drifting by 100.8 percent (table 3). The level of conduct of developmental drifting with the mechanized loading of coal and rock was 76.8 percent (table 4). Almost a fourth of all drifting, where loading is required, is now being conducted by drifting cutter-loaders, and in the Dobropol'yeugol' [Doboropol'ye Coal-Mining Association], Pavlogradugol' [Pavlograd Coal-Mining Association], Ukrzapadugol' [Coal-Mining Association of the Western Ukraine], and Aleksandriyaugol' [Aleksandriya Coal-Mining Association] this indicator is much higher. The number of drifting brigades that work with speedy methods is growing. During the first half of the year the republic's coal-mining industry had 198 brigades for high-speed mining. They did 257.02 km of developmental drifting.

Coal preparation workers also worked successfully in 1979 (table 5). During the first half of the fourth year of the Tenth Five-Year Plan, 780,000 tons of coal were prepared and 303,000 tons of concentrate produced above plan requirements. The plan for preparing coal and producing concentrate for coking was overfulfilled. The plan for producing lignite briquettes was underfulfilled.

The operating results of advanced coal-mining brigades during the first half of the year testifies to the constant single-mindedness of laboring collectives to achieve high results and to search for and use internal production reserves. The mining brigades of A. Ya. Kolesnikov from the Molodogvardeyskaya Mine (Krasnodonugol'), N. N. Skrypnik from the sh/u [mine administration] imeni Frunze (Donbassantratsit), A. D. Polishchuka from the Trudovskaya Mine (Donetskugol'), V. M. Borisenko from the sh/u imeni Lenin (Voroshilovgradugol'), A. A. Asyutchenko from the Mine imeni Gazeta Sotsialisticheskiy Donbass (of Donetskugol'), G. I. Motsaka from the Mine imeni Kosmonavtov (Donbassantratsit) and V. I. Ignat'yev from the Krasnolimanskaya Mine (of Dobropol'yeugol') and many other brigades worked most productively.

Table 2

Производственные объединения (1)	(2) Комплексно механизированные забои, оборудованные комбайнами и стругами на пластах с углом падения до 35°			
	Количество (3)	Добыча, тыс. т (4)	% к добыче из действующих очистных забоев на пластах с $\alpha < 35°$ (5)	Нагрузка на лаву т сут (6)
Донецкуголь (7)	49	5091	47,2	635
Макеевуголь (8)	38	4000	55,6	658
Красноармейскуголь (9)	51	4290	70,6	554
Добропольеуголь (10)	30	4215	81,8	904
Шахтерскантрацит (11)	20	1587	26,7	519
Торезантрацит (12)	39	3222	63,5	541
Ворошиловградуголь (13)	23	3024	59,4	719
Стахановуголь (14)	14	1046	25,6	466
Первомайскуголь (15)	17	1581	36,7	620
Краснодонуголь (16)	30	3358	88,3	694
Донбассантрацит (17)	45	4996	47,2	708
Свердловантрацит (18)	37	4238	94,9	774
Павлоградуголь (19)	49	4086	93,0	572
Укрзападуголь (20)	59	5711	76,0	649
Александрияуголь (21)	13	1511	100,0	813
Минуглепром УССР (22)	516	51956	60,4	652

Key:
1. Production associations.
2. Mine faces with integrated mechanization and equipped with cutter-loaders and overhead cutters for seams with dip angle of less than 35°.
3. Number.
4. Output, thousands of tons.
5. Percent of output from active breakage faces at seams with $\alpha < 35°$.
6. Workload per longwall, thousands of tons.
7. Donetsk Coal-Mining Association.
8. Makeyevka Coal-Mining Association.
9. Krasnoarmeysk Coal-Mining Association.
10. Dobropol'ye Coal-Mining Association.
11. Shakhtersk Anthracite-Mining Association.
12. Torez Anthracite-Mining Association.
13. Voroshilovgrad Coal-Mining Association.
14. Coal-Mining Association imeni A. G. Stakhanov.
15. Pervomaysk Coal-Mining Association.
16. Krasnodon Coal-Mining Association.
17. Donbass Anthracite-Mining Association.
18. Sverdlovsk Anthracite-Mining Association.
19. Pavlograd Coal-Mining Association.
20. Coal-Mining Association of the Western Ukraine.
21. Aleksandriya Coal-Mining Association.
22. UkSSR Ministry of Coal Industry.

Table 3

Производственные объединения (1)	(2) Проведение подготовительных выработок					
	(3) всех			(4) вскрывающих и подготавливающих		
	План, км (5)	Факт., км (6)	% к плану (7)	План, км (5)	Факт., км (6)	% к плану (7)
Донецкуголь(8)	149,9	153,0	102,1	105,6	109,9	104,1
Макеевуголь(9)	108,1	109,1	100,9	74,3	76,4	102,8
Красноармейскуголь(10)	85,1	86,4	101,5	75,4	73,0	96,8
Добропольеуголь(11)	86,4	96,9	112,2	60,7	64,2	105,8
Артемуголь(12)	161,8	165,6	102,3	82,1	82,1	100,0
Орджоникидзеуголь(13)	61,5	68,5	111,4	36,7	37,1	101,1
Шахтерскантрацит(14)	72,6	76,0	104,7	47,4	48,7	102,7
Торезантрацит(15)	65,7	77,3	117,7	42,9	45,3	105,6
Ворошиловградуголь (16)	86,7	90,4	104,3	49,5	49,9	100,8
Стахановуголь(17)	106,8	105,8	99,1	61,8	60,1	97,2
Первомайскуголь(18)	81,9	75,9	92,7	58,3	54,1	92,7
Краснодонуголь(19)	61,8	66,3	107,3	42,3	43,4	102,6
Донбассантрацит(20)	137,4	139,4	101,5	74,4	74,9	100,7
Свердловантрацит (21)	54,1	56,0	103,5	37,0	37,6	101,6
Павлоградуголь(22)	59,4	59,4	100,0	56,5	54,4	96,3
Укрзападуголь(23)	69,4	73,0	105,2	60,1	63,3	105,3
Александрияуголь (24)	14,5	14,2	97,9	13,3	13,2	99,2
Минуглепром УССР(25)	1463,1	1506,8	103,0	979,3	987,6	100,8

Key:
1. Production associations.
2. Conduct of developmental drifting.
3. All drifting.
4. Stripping and developmental drifting.
5. Plan, km.
6. Actual, km.
7. Percent of plan.
8. Donetsk Coal-Mining Association.
9. Makeyevka Coal-Mining Association.
10. Krasnoarmeysk Coal-Mining Association.
11. Dobropol'ye Coal-Mining Association.
12. Artemovsk Coal-Mining Association.
13. Ordzhonikidze Coal-Mining Association.
14. Shakhtersk Anthracite-Mining Association.
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Table 4

(1)	(2)				
	План, км (3)	Факт, км (4)	(5)	(6) (3)	(4)
Донецкуголь (7)	117,5	118,6	77,5	41,8	41,9
Макеевуголь (8)	76,0	77,2	74,2	24,9	26,8
Красноармейскуголь (9)	62,1	65,0	75,2	20,8	20,8
Добропольеуголь (10)	81,2	92,0	94,9	59,4	67,4
Артемуголь (11)	79,8	79,8	100,0	6,2	3,0
Орджоникидзеуголь (12)	34,9	34,9	94,1	1,3	0,3
Шахтерскантрацит (13)	46,9	47,2	62,1	11,3	12,7
Торезантрацит (14)	41,6	43,6	62,7	4,3	2,2
Ворошиловградуголь (15)	61,0	61,9	76,6	12,2	13,2
Стахановуголь (16)	72,5	74,4	81,6	2,9	1,9
Первомайскуголь (17)	56,5	46,5	65,0	7,5	6,1
Краснодонуголь (18)	43,8	46,5	86,9	11,5	11,5
Донбассантрацит (19)	70,5	64,1	52,8	6,0	4,6
Свердловантрацит (20)	35,2	36,1	64,5	2,3	0,6
Павлоградуголь (21)	59,2	57,4	98,0	56,5	55,6
Укрзападуголь (22)	97,5	98,5	80,1	33,1	33,9
Александрияуголь (23)	12,8	11,9	83,8	12,8	11,9
Минуглепром УССР (24)	1009,0	1015,6	76,8	314,0	314,4

Key:
1. Production associations.
2. Conduct of developmental drifting with the mechanized loading of coal and rock.
3. Plan, km.
4. Actual, km.
5. Percent of total length of conduct of drifting, where loading is required.
6. Including drifting by cutter-loaders.
7. Donetsk Coal-Mining Association.
8. Makeyevka Coal-Mining Association.
9. Krasnoarmeysk Coal-Mining Association.
10. Dobropol'ye Coal-Mining Association.
11. Artemovsk Coal-Mining Association.
12. Ordzhonikidze Coal-Mining Association.
13. Shakhtersk Anthracite-Mining Association.
14. Torez Anthracite-Mining Association.
15. Voroshilovgrad Coal-Mining Association.
16. Coal-Mining Association imeni A. G. Stakhanov.
17. Pervomaysk Coal-Mining Association.
18. Krasnodon Coal-Mining Association.
19. Donbass Anthracite-Mining Association.
20. Sverdlovsk Anthracite-Mining Association.
21. Pavlograd Coal-Mining Association.
22. Coal-Mining Association of the Western Ukraine.
23. Aleksandriya Coal-Mining Association.
24. UkSSR Ministry of Coal Industry.

Table 5

Indicators	Plan, thousands of tons	Plan fulfillment: Thousands of tons	% of the plan	% of the 1st half of 1978
Coal processed at preparation plants	67,540	68,320	101.2	103.0
Coal processed at mechanized sorting installations	5,493	5,636	102.6	99.6
Output of concentrate	40,440	40,743	100.8	101.1
Output of coal of large and medium sizes	12,669	12,751	100.6	99.9
Including anthracite	9,084	9,148	100.7	101.6

In all, 124 ROZ [breakage-face workers] brigades provided for the mining of 1,000 tons or more of coal per day from one breakage face and sent to the surface 29.58 million tons of coal during the first half of the year. The planned volume of state capital investment was mastered for UkSSR Minugleprom as a whole by 103 percent, and the included plan for construction and installing operations as a whole by 99.9 percent, and, with regard to facilities for production purposes, the plan for assimilating capital investment was fulfilled by 104 percent, the included plan for construction and installing operations by 102 percent.

The Mine imeni Geroyev Kosmosa of Pavlogradugol' was introduced into operation at the designed capacity of 1,500 tons of coal per year. The Krasnyy Partizan Mine of Sverdlovantratsit [Sverdlovsk Anthracite-Mining Association] was rebuilt and its annual capacity increased by 70,000 tons.

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FUELS AND RELATED EQUIPMENT

PROGRESS, PROBLEMS OF UKRAINIAN COAL MINE CONSTRUCTION RECITED

Kiev UGOL' UKRAINY in Russian No 8, Aug 79 pp 1-4

[Article by V. A. Voronin, First Deputy Minister of UkSSR Ministry of Coal Industry: "The Ukraine's Drift Miners--for Miners' Day"]

[Text] The republic's miners, like the whole Soviet people, will observe their traditional vocational holiday--Miners' Day--on 26 August 1979. One can state confidently that the republic's coal industry has taken a significant step forward. Our mines are equipped with productive machinery and are enterprises with a high technical level of production organization.

The creation and introduction of new equipment for mechanizing breakage faces, plus an expansion in the area of use of existing equipment, have enabled the level of coal mining by mechanized complexes to be increased 3.5-fold (19-fold for seams with thicknesses of less than 1.2 meters), cutter-loader mining 3.3-fold, and conveyerization on inclined workings 1.4-fold in comparison with 1970. Work has practically been completed on mechanization of the more labor-intensive processes, namely, breakage-face loading (97.4 percent), the stripping and development of horizontal workings (95 percent) and the conversion of fixed and industrial complexes on the surface to automatic and remote control (95 percent). Work has been done to improve underground transport through the use of belt conveyors, heavy-load mine cars and heavy electric locomotives and through the mechanization of auxiliary operations. The level of conveyorization has reached 50.6 percent at sloped workings, 20 percent at horizontal workings.

The initiators of many valuable innovations to raise the utilization effectiveness of mine equipment, to achieve thousand-ton workloads and to mine speedily are making a major contribution to the development of the coal industry. In the Ukraine 132 brigades of breakage-face workers are meeting the workload of 1,000 or more tons per day. These brigades, which make up about 10.1 percent of all mining brigades, produced in 6 months of 1969, 24.7 million tons of coal, or 34.1 percent, of the coal mined at gently sloping beds with dip angle of less than 35 degrees. The workload per longwall of the thousand-tonner brigades exceeds 3.4-fold the average amount of coal mined daily at breakage faces, and the labor productivity in these collectives is 2.8-fold higher than the average indicator for the industry. In 20 brigades, the average labor productivity of ROZ's [breakage-face workers] reached 500-1,000 tons per month.

The republic's underground coal mines are widely supporting the initiative, which the Central Committee of the Ukrainian Communist Party approved, of 10 advanced brigades that are promoting competition for an increase in the workload per longwall and are excavating thin seams. Following the innovators' example, 182 brigades are mining 500 tons or more of coal per day from thin seams.

Timely preparation of a breakage front acquires especially great importance where the work pace of brigades that operate mechanized equipment is rapid. At present there is a disproportion in the levels of mechanized mining and of development. Several factors (increase in temperature and the outbursts hazard, the need to increase the cross-section area of the drifting that is being done and density of roof-support installations, and other factors) connected with an increase in the depth of excavation reduce the pace of mine development operations. In recent years, much work has been done at the Ukraine's underground mines to reequip development breakage faces and to raise the mechanization level of drifting. The fleet of highly productive 1PNB-2 and 2PNB-2 loaders increased 4.5-fold (over 1970) and the introduction of 2PNB-2B loaders with toolbar drilling equipment began. By the end of 1979 there will be 1,020 such machines in the fleet. The fleet of drifting and cutting cutter-loaders grew 3.1-fold, and it is constantly being improved: being introduced are heavy 4PP-2 type cutter-loaders that can excavate rock with a strength of up to 6, GPK cutter-loaders (to replace the PK-3), and KN cutting cutter-loaders. The level of conduct of development working with the mechanized loading of coal and rock was increased by 17.2 percent; it is now 76.6 percent, while for drifting cutter-loaders it is 23.2 percent.

Ways to improve mine-development work at underground mines and to introduce progressive technology were defined. Basically, these include:

The organization of operations at developmental faces under production schemes that are based upon progressive equipmental and technological solutions;

A concentration of development work that calls for a reduction in the number of simultaneously operating development faces, based upon the creation of consolidated integrated brigades;

Provisioning for growth in the number of high-speed drifting brigades;

The organization of drifting-brigade operations under the contracting method; and

The creation of specialized brigades to prepare development workings and of brigades of rigging workers for the delivery of materials to the mine face.

A high level of engineering solutions and the scientific organization of work, combined with vocational skill of the workers, solidarity and a high state of discipline, have enabled a number of advanced brigades to improve work indices substantially. The brigade of Hero of Socialist Labor, Lenin Prize winner I. D. Zinchenko from the Mine imeni Abakumov of Donetskugol' [Donets Coal-Mining Association], has played a great role in the assimilation of advanced technology and the organization of drifting operations on a new qualitative basis. This brigade, using the PK-3 cutter-loader, in October 1963 drove 1,113.2 meters of heading face, 1,826 meters in January 1966, and 1,851 meters in June 1967 with two heading faces. The brigade's initiative and advanced methods and modes of operation have been propagated within the industry.

The brigade of V. G. Vendilovich, which in 3.5 years of the five-year plan did more than 14 km of drifting, has been working with excellent indices at the Mine imeni Abakumov. In 1979 the brigade came out with a number of initiatives: to provide in 1979 for an average monthly drifting speed of 295 meters, to carry out the plan for the first 4 years of the five-year plan by the second anniversary of the new USSR Constitution; to carry out the five-year plan by the 110th anniversary of V. I. Lenin's birth; and to extend assistance to D. A. Goncharov's drifting brigade. In supporting these initiatives, 32 drifting brigades in the Donbass [Donets Coal Basin] undertook commitments to drive 80 km in 1979.

D. G. Khomich's drifting brigade from the Chervona Zirka Mine of Torezantratsit [Torez Anthracite Association] is systematically achieving high indices. In 3 years of the Tenth Five-Year Plan the brigade, by using the blasthole drilling method and the 1PNB-2 loading machine, did 9.4 km of drifting and in March 1979 made 1,117 meters of prefabricated passageways.

After carefully studying processes of rapid drifting and after developing a precise schedule, I. N. Vinskiy's brigade from the Mospinskaya Mine of Donetskugol' did 405 meters of cross-cutting of hard rock in April 1979.

Thanks to the creation of high-speed drifting brigades, the amounts of development drifting of Dobropol'ugol [Dobropol'ye Coal Mining Association] mines increased greatly. In April 1979, at the Pioner Mine, which uses hydraulic operations, I. S. Suslev's brigade did 703 meters of ventilation drifting, and in May N. E. Stepin's brigade (from the Krasnolimanskiy Mine) did 1,335 meters of ventilation drifting in 31 work days. The average daily pace was 43.1 meters, and labor productivity per drifter was 12.2 meters per month. The face was equipped with the GPK cutter-loader and an experimental model of the 1LTP-80 telescoping belt conveyor.

Great successes are being achieved also by the mine builders' best drifters' collectives. A. N. Nosov's brigade at the Zhdanovskaya-Kapital'naya Mine did more than 1.9 km of drifting in 7 months. V. I. Burnov's brigade is building Zapadno-Donbasskaya Mines Nos 16/17; in the first 7 months of 1979 it did about 1,630 meters of drifting, at an average monthly pace of 233 meters.

At the Mine imeni Kalinin of Donetskugol' the brigade managed by V. A. Nelepinskiy from Drift Mine Construction Administration No 4 of Donetskshakhtoprokhodka [Donets Underground Mine Drifting Trust], using the SK-1u mine-shaft drifting complex, made 160 meters of vertical shaft 46.5 square meters in cross-section in 30 workdays in March 1979, achieving a shift record for labor productivity of 15.02 cubic meters of finished shaft per drifter.

Altogether 212 high-speed brigades did 26 percent of all drifting at UkSSR Minugleprom mines in 1979, the average speed was 212 meters per month, which is 2.4-fold the average for the ministry.

The republic's miners face a complicated task: they should in the near future modernize the mining activity of a number of mines, reduce transport networks and eliminate stages thereof, improve mine ventilation and convert highly productive breakage faces over to progressive ventilation schemes, continue to convert breakage faces to pillar-mining, and so on. In order to solve the task, a substantial increase in development work, including workings specially designated for improving the mining activity, and the preparation of ventilation and support shafts and holes are called for. Even in 1979, 3,193.4 km of development working must be done by the in-house method (which is 280.6 km more than in 1978), and the mine builders should do 360.5 km of drifting.

In preparing a worthy greeting for Miners' Day, the drifters are coping successfully with established plans and tasks and are undertaking increased commitments. In the first 6 months of the year, 43.1 km of all the development workings, including 8.3 km of stripping face and developmental shortwall mining, were above the plan.

Because of the need to increase mine-development work, new tasks have been set in the area of organizing drifting, and the requirements for the technical level and for the creation of effective equipment have been raised. The 4PP-5 and GPK-2 cutter-loaders, with an arrow-like working implement, are being used in operations by the composite method where rock strength is less than 6. Improvement of the Soyuz-19 rotary drifting cutter-loader for doing mainline work 17-20 square meters in cross-section and parallel to the deposit, in rock of strengths 6-8, continues. Series production of Titan gob-crushing complexes created by Dongiprouglemash [Donets State Design, Planning and Experimental Institute for Coal-Industry Machine Building], jointly with Donugi [Donets Scientific-Research Institute for Mining], which will enable the technical and economic indices for gobbing work to be increased, has started. Use of the complex at the Trudovskaya Underground Mine of the Donetskugol' Association at the section under twice Hero of Socialist Labor I. I. Strel'chenko helped to mechanize rock-gobbing operations, to reduce drifting brigade manpower by 25 persons, to improve the status of the work being supported, and to increase the workload per longwall by up to 4,000 tons per day.

Donugi, jointly with the Kopeysk Machine-Building Plant imeni Kirov, Giprouglemash [State Design, Planning and Experimental Institute for Coal-Industry Machine Building], and other organizations, worked out the technology and a set of KSV [paired-drifting complex] equipment for the conduct of paired drifting with a common advancing coal face and gobbing of the worked space between them with rock. In 1979 the fabrication of test models will be finished and testing will start, and in 1981 serial production thereof will begin. Equipment has been created for the conduct of paired drifting along slightly sloped seams less than 0.9 meter thick with auger removal of the coal between them.

A backlog of accomplished scientific, design and production work will enable the production of drifting equipment complexes to be started in the next few years. The work has been aimed at the creation of:

Drifting complexes based upon the GPK-2, 4PP-2 and 4PP-5 cutter-loaders that will enable the process of breaking and loading of the mined mass and the erection of supports, including a 4PP-2Shch complex with remote control for doing breakage along seams where there is an outburst hazard, to be completely mechanized;

Sets of equipment for cutting operations on sloping and slightly sloping seams 0.9-1.6 meters thick; and

KGV-1 blasthole drifting complexes, for breaking work and for supporting horizontal workings more than 19.3 square meters in cross section, in rock with strength greater than 6.

Questions of mine supports and preservation of the workings become increasingly important as depths increase. The main support in development working is the pliant metal arch made of special fluted section. A parametric series of SVP shapes that depend functionally upon the width of the working of standard cross-sections has been developed for such supports. The introduction of five standard sizes of SVP shapes has enabled a saving of more than 5 million rubles per year.

Special supports with directional constructional pliancy have been developed. These are the AP-5 and AKP-5 metal arches for gently sloping seams and the PAK for steep seams. Pliant supports of increased load-bearing capability are being introduced in rectangular workings. In 1979 the production of supports made of low-alloy steel, which reduce specific metal-support consumption considerably, began. Joints of AP support elements which provide stability characteristics are being created and introduced, and the reliability of supports and work safety are being increased.

The erection of supports remains a heavy, labor-intensive process in the drifting cycle. TsNIIpodzemmash [Central Scientific-Research Institute for Underground Mining Machinery] and the NPO Uglemekhanizatsiya [Science and Production Association for Coal Mechanization] are engaged in the development of mechanized means for installing supports. However, there are no solutions that will allow the entire support process, including the installation of frame sets and lags and the filling of the secured space, to be mechanized.

The Ukraine's miners are calling the attention of scientists and machine-builders to the need to create new types of drifting equipment. Thus, the possible volume of use of PK-9r and GPK cutter-loaders has now been exhausted, and machines, thanks to which cutter-loader drifting (using the 4PP-2 cutter-loader and KN cutting complex) can be expanded, are not being supplied in adequate numbers. A drifting cutter-loader able to effectively destroy rock with a strength of 600-800 kg-force/cm^2 is lacking. Because of an inadequate number of 1PNB-2B and 2PNB-2B drilling and loading machines with toolbar drilling equipment, only 5 percent of the total amount of breakage is being accomplished. The technology of breakage that uses PNB type machines without toolbar equipment is very far from being perfected, since the process of drilling blastholes, especially with electric-core drills, is greatly complicated. All the time gained as a result of growth in loading productivity is lost because of the increased time taken to drill blastholes.

The 1PNB-2u machine for working slopes that was turned over for series production is not being manufactured. Development faces are not being adequately supplied with equipment for mechanizing auxiliary transport (4DMK and 6DMK monorail ways), the mechanization of support work (KPM) and the loading and unloading operations (tractors and TP lifters); this hampers development of the integrated mechanization of drifting operations.

Despite the high effectiveness of use of the Titan complex, the Yasinovataya Machine Building Plant is producing them in small numbers. The development faces of underground mines that are excavating steep seams are being converted extremely slowly to highly productive machinery with electric drive. Mine construction workers are being supplied inadequately now with special drifting equipment: BUK-2 concrete-laying complexes, OMP movable metal formwork, and complex for the sinking and deepening of shafts.

All-Union scientific and technical conferences on the status and prospects for improving drifting work at coal-industry enterprises were held in the cities of Shakhta and Karaganda in April 1979. The conference's recommendations about improving the management structure of mine-development operations and planning the volume and organization of work and production and the technology and equipment for mechanization are being introduced successfully at the republic's underground mines.

Rich traditions and the work experience of advanced collectives, combined with privileges and advantages for miners and with further reequipping of the industry with machinery, creates favorable opportunities for highly productive labor, more complete use of reserves and, based thereon, fulfillment of the tasks set for the republic's mines by the 25th CPSU Congress of providing the country's economy with cheap, high-quality fuel.

END

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